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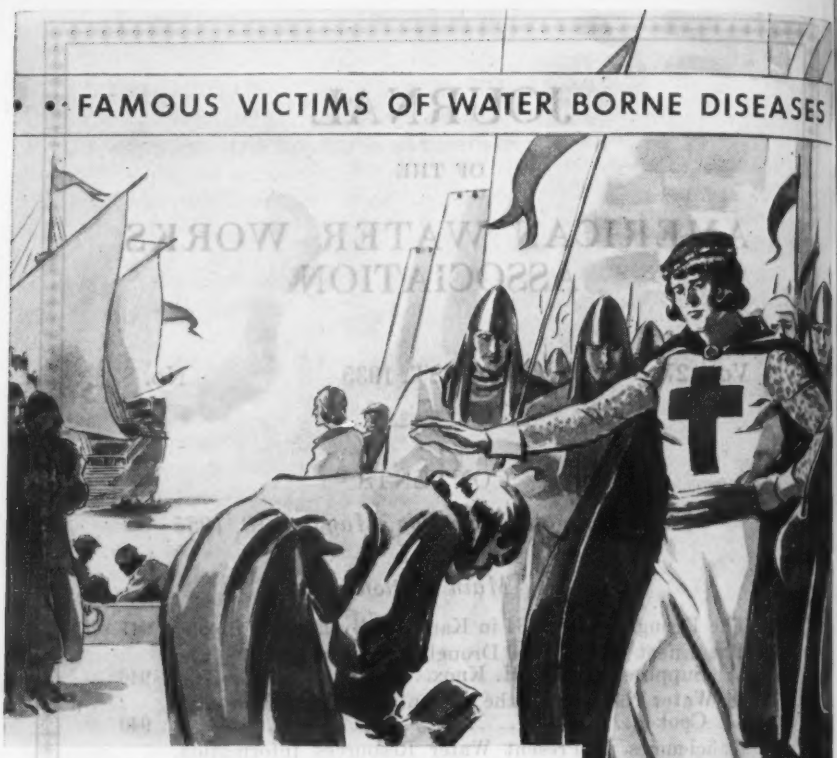
FAMOUS VICTIMS OF WATER BORNE DISEASES



LOST TO A GREAT CAUSE...

LOUIS IX, *Crusader*

WHEN Louis IX—King of France—sailed on his Second Crusade, no one had even dreamed of CHLORINATION, the universal protection of drinking water. Had it then been known perhaps his army would have reached the Holy Land,—instead of of experiencing that sorry plight at Tunis sixty days later when more than half were dead and dying from sickness and Louis himself succumbed to dysentery—a water-borne disease.

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Discussion of all papers is invited

Vol. 27 AUGUST, 1935 No. 8

THE DROUGHT OF 1930–34 IN KANSAS

By Earnest Boyce
(Chief Engineer, State Board of Health, Lawrence, Kans.)

The rainfall shortages of the past few years have greatly stimulated popular interest in water conservation measures, especially in those regions where the water resource furnishes the limiting factor in further economic development.

It is proper that water supply engineers not only give time to a discussion of the physical effects produced by the drought, but also that they carefully analyze the various possible remedial measures. This is particularly important in view of the fact that the economic stress produced by the drought and the consequent necessity for emergency procedure may crystallize sentiment in favor of certain conservation programs before proper engineering and economic consideration can be given to all phases of the problem.

The lure of cheap land combined with the possibilities of tractor farming on an extensive scale has been largely responsible for a significant change during the past fifteen years in the agricultural development of an area with little or no margin of safety as regards an adequate annual rainfall.

If, through a cycle of years, the rainfall has been adequate to the needs of agriculture, it is easy to assume that this cycle has contained

in it all the normal variations of rainfall to be anticipated. When this assumption is disproven by a cycle of years giving something less than the minimum rainfall necessary for the support of agriculture and a dependent industrial development that has taken place, then a crisis occurs.

Had a proper analysis been made of the annual variations of the previously occurring rainfall, it might have been predicted with reasonable certainty that variations from the average annual rainfall as great as those that are now being observed, would occur.

The fallacy of a popular opinion that in some strange way due to agricultural development, an increase in the average annual rainfall was being experienced, has been established.

While every region of deficient rainfall and every drought may be expected to produce a crop of rain makers, it is yet to be established that man can modify climatic conditions to the extent of effecting a change in the annual variation and amount of rainfall reaching any given area.

The growing of agricultural crops, without the aid of irrigation, is sharply limited by the amount and distribution of rainfall. Consequently, the most immediate effect of any drought is the partial destruction of agricultural production.

For all usages of water except the growing of crops, we are dependent for the most part on the natural storage provided by porous geological formations. Hence a discussion of the effect of the drought in any area resolves itself into a discussion of the available storage facilities.

Climatological and geological conditions combine to make impossible a general statement regarding the drought effect in Kansas.

The state extends from east to west from a region with an average annual rainfall in excess of 40 inches to the western border where less than one-half this amount may be anticipated.

Kansas soil regions outline areas that vary widely in their capacity to provide water storage. Northwestern Kansas is covered with wind deposits that overlie residual soils of the Tertiary period. The coarse granular nature of the western residual soils reflect their granitic origin and because of their extent and high water yield are important aquifers. They overlie shale beds of irregular conformation whose depressions collect the water and make it available for well development.

The alluvial deposits of the Arkansas and Kansas river valleys

cover large areas and make an important contribution to the underground water resources of the state.

In eastern Kansas the older geological formations are exposed and the soils are those that result from limestone, sandstone, and shale disintegration. Except for local sandstone and limited alluvial deposits, the underground water resources in eastern Kansas are generally unsatisfactory. Consequently, eastern Kansas municipal supplies are for the most part obtained from impounding reservoirs or from rivers and river storage. Rural water supplies are obtained from wells in limited local water-bearing formations and from cisterns, supplemented by stock water ponds and river channel storage where available.

In general, Kansas municipalities have been fortunate during the period of the drought in that most of the 330 municipal supplies have been developed with a sufficient margin of safety to avoid serious shortage. The few cities experiencing water shortage during this period were known to have had an inadequately developed water supply, and the shortage was anticipated.

As the drought progressed, a serious condition developed in rural areas, particularly in the central and eastern section of the state. The lowering of the water table rapidly depleted small stream channel and stock water pond storages. Farm well supplies ample for domestic needs were generally inadequate to meet the added stock water requirements and a general failure of farm water supplies resulted. Farmers were compelled to haul water for stock purposes, sometimes over considerable distances. Many municipalities responded in the emergency by furnishing water to the farmers of their trade territory.

DROUGHT RELIEF SERVICE

Prompt action was taken by the state government in the organization of a drought relief service as a part of the work of the Kansas Relief Committee, the state organization of the F.E.R.A. Several hundred pumping units were loaned by oil producing companies to be used for pumping water from rivers, creeks, and ponds into storage tanks placed on the bank from which farmers and stockmen would haul water.

An emergency water conservation program was organized for the principal purpose of giving immediate relief where water shortages were acute by developing such storages as might exist. In addition to this emergency work, a work relief program was planned for the

purpose of increasing storage facilities by the construction of stock water ponds in the eastern part of the state. In the western part of the state a garden pond or earth tank program was inaugurated for the purpose of making garden tract irrigation possible from well water sources.

A rather extensive program of community well development was undertaken. A staff of geologists was organized by the state relief agency utilizing work relief for the purpose of putting down test wells. When an adequate supply was located, county relief labor was used for constructing a well, the pumping equipment and material being furnished by the county. The land owner on whose farm the wells were built gave easement to the county, which easement provided that whenever the board of county commissioners declared that a water supply emergency existed, the well would be made accessible for public use.

To prevent the silting of existing and newly constructed ponds where cultivated areas formed a portion of the water shed, soil erosion control projects were included. These projects were included as a part of the pond building program. The erosion control program included terracing and the development of proper vegetative covering.

The policy of the relief organization as regards municipal water supplies is expressed in the following quotation:

"The Water Conservation Program of the Kansas Emergency Relief Committee includes provisions for aiding cities, though work relief projects to strengthen their water resources where they are now being affected by the drought; that is, if a city has a shortage of water, or needs an additional well, some additional pipe laid, the ground water supply reservoir increased in capacity, or a drainage area improved, it can make a work relief project for any of those purposes."

A great many cities are taking advantage of the availability of relief labor and strengthening the reserve capacity of the municipal supply. A great deal of constructive work has resulted from this emergency program. The use of trained geologists for well location has increased popular interest in ground water geology. Farm ponds have been located and constructed with due regard to runoff and storage capacity, and the application of simple engineering and geological principles by technically trained personnel has had an educational effect that should result in a better popular conception of some

of the problems of water conservation. As the emergency passes it will become increasingly important that a careful analysis be made of the whole problem of water storage and utilization.

FUTURE STUDY

Where agriculture is involved a study of land use including the possibilities of irrigation is essentially a study of the amount of water resource available. Plans should not be made on the basis of the present abnormal drought conditions. There is just as much danger that the assumption will be made that the present rainfall deficiency will continue as formerly existed with regard to an increased annual rainfall. Land use policies should not be formulated without a statistical analysis of local rain fall records.

Water storage facilities should be surveyed and geological formations studied with regard to the possibility of further development of ground water both by works for the recovery of the underground water and by works for increasing the recharge rate.

In conclusion, may we suggest that haste in this program will not permit the careful analysis of all aspects of the water conservation problem. It is unfortunate that society has not seen fit to permit the careful assembling of basic data over a long period of years and has suddenly demanded of water resource engineers a well balanced program for immediate construction. The best possible program that can be developed under these conditions will be something short of what the engineer might hope for had time permitted the careful basic research that should form the background for the extensive program being contemplated.

THE EFFECT OF THE 1934 DROUGHT ON OHIO PUBLIC WATER SUPPLIES

By W. H. Knox

(*Assistant Engineer, State Department of Health, Columbus, O.*)

According to the reports of the Ohio office of the Weather Bureau "the year 1934 has the distinction of being the driest year in the last 52, not excepting 1930." The normal precipitation for the entire state of Ohio is 37.75 inches. In 1930 the average precipitation was 27.00 and in 1934 for the entire state was 26.56 inches. The year 1934 was the fifth consecutive year when the precipitation has been below normal in Ohio.

This deficient precipitation has naturally had an effect upon the public water supplies of the state. Notwithstanding that 1934 was drier than 1930, the municipal water supplies of the state have, generally speaking, not been so acutely affected in 1934 as they were in 1930.

As in 1930, the cities and villages most seriously affected by water shortages have been municipalities such as Bellevue, Bucyrus, Delaware, Springfield, Barnesville, Blanchester, Caldwell, Eaton, Marysville, New Concord and Wauseon which depend upon surface water supplies. In practically all of these communities a water shortage could have been avoided by provision of adequate facilities for storage of water. Ten of these eleven municipalities have already taken steps to provide additional storage reservoirs or other emergency supplies.

In other cities depending on surface supplies the storage facilities were drawn upon to an extent much greater than ever before. In Columbus, for example, stored water was withdrawn continuously from May, 1934 to March, 1935. The degree to which the reservoir water levels receded was the cause of considerable alarm to the layman and there was much newspaper publicity when the reservoirs overflowed again in March, 1935. During the drought a Columbus water works official was questioned regarding the possibility of the city experiencing a water shortage. He replied that he was worried not concerning the adequacy of the supply, but that the water stored

would be very hard and hence expensive to soften. Water works officials can have this confidence where there is a well-planned water supply. Similar experiences occurred in other Ohio municipalities where adequate water storage facilities are provided.

Ohio experiences prove that, even in drought years such as 1930 and 1934, there is sufficient precipitation to supply the water supply needs of the municipalities if adequate storage facilities are provided. The water works officials must, however, assume that drought years as severe as 1930 and 1934 may be encountered again and must plan accordingly. Past assumption of safe run-offs and yields of water sheds must be drastically revised if adequate water supplies during drought years are to be assured.

The ground water supplies, especially those from deep wells, probably were as much affected by the deficient rainfall during the previous four years as they were by the deficient rainfall during 1934. Shallower well supplies were, of course, quickly affected by the 1934 drought. Farmers' wells in many sections of the state completely dried up. Since the public water supplies obtained from ground water generally draw from deeper strata, these supplies were not so seriously affected.

Water shortages of varying degree were reported in some thirty municipalities in the state. In no case, however, were the shortages as acute as those reported in 1930. At many of these cities and villages the shortages were relieved by installation of additional wells or by new well pumps equipped to draw water from lower elevations. At a considerable number of these places no constructive work has yet been done and they face another shortage if a drought occurs.

Considering the large number of public water supplies obtained from ground water, comparatively few water shortages were reported in 1934. This may be due in part to lower domestic and industrial demands caused by the depression, but is mainly due to the fact that most of the water supplies are well planned. Undoubtedly there is, in many sections of the state, a lowering of ground water levels due to the continued deficient precipitation of the last five years. Data on this subject are very meager. Various misinformed groups, sometimes well-meaning and sometimes with selfish interests, have advocated various measures to raise ground water levels. One of the principal measures advocated is the construction of reservoirs which are supposed to store surface water until it has percolated into the ground.

The only way in which ground water levels can be raised is by normal or excess precipitation over a period of time. In Ohio municipalities where ground water supplies have been deficient in the past, water shortages can be averted only by the application of sound water works principles and not by untried hypotheses. Where shortages have occurred we have advised municipalities to plan additional wells in existing or new well fields, to change pumping equipment so that water may be drawn from deeper levels, or, where adequate ground water is extremely doubtful, to substitute a surface supply for the ground water supply.

Summing up the general situation in the 450 cities and villages in the state having municipal water supplies, it is gratifying to note that the large majority of these water works systems were not seriously affected by the unprecedented droughts of 1930 and 1934. This experience is a credit to the wise planning and efficient operation of these systems by water works men. The principal lesson for water works men which can now be drawn from the 1930 and 1934 droughts, is that such experiences may occur again and that we must take all steps possible in advance to minimize the effects of such droughts. With these recent occurrences as reminders, and the conservative background of the water works profession as a guide, there need be little concern regarding the future of our public water works systems even in case of another severe drought.

ON WATER PLANNING FOR THE NATION

By Morris Llewellyn Cooke
(*Consulting Engineer, Philadelphia, Pa.*)

In a very portentous sense the solution of our water problems is essential to national survival. Recurring droughts and dust storms bear witness to the truth of this statement. Speaking in terms of generations only—and a very few at that—unless the depletion and erosion of our soils, everywhere detectable, is stopped, one more spectacular and promising episode in the life of the race will have run its course. Removed as so much of its area is from oceans and other large bodies of water, and with its agriculture and climate what they are, the United States of America is not a permanent country in the sense that those of North Europe are permanent.[1]

The hydrologic cycle (figure 1) is the name we have given to the series of phenomena through which water evaporated from the lands and oceans manoeuvers above, on and below the surface of the land before being absorbed back into the vast reservoirs from whence it came. And the manner in which we adjust our civilization to this sequence of events can spell either prosperity or decay. My theme today is our responsibility for the use and control of water—wherever it may be. This responsibility lies almost wholly at the door of the engineering profession.

One of America's great teachers—Shaler of Harvard—once said of the soil: "It is now a question whether human culture, which rests upon the use of the soil, can devise and enforce ways of dealing with the earth which will preserve this source of life so that it may support the men of the ages to come. If this cannot be done we must look forward to the time—remote it may be, yet clearly discernible—when our kind, having wasted its great inheritance, will fade from the earth because of the ruin it has accomplished."[2]

This had about as much interest for us as has the diplococcus or

[1] See "Is the U. S. a Permanent Country, like North Europe"—a paper read by Arthur J. Mason, before the Chicago Literary Club, in April, 1920.

[2] "Economic Aspects of Soil Erosion," Nathanial S. Shaler National Geographical Magazine, Vol. 7, 1896, Nov., p. 374.

one of Cleopatra's nights, until it began to dawn on us that the gaunt figure of this prophecy was knocking at the door of our own Union of States. Particularly in the decades since 1900, we have pillaged our soils at a tempo of which Shaler probably never dreamed. We have ruthlessly cut down and burned off our forests. Through improvident grazing over vast areas the protective sod cover has been removed. In both moist and dry areas we have practiced modes of agriculture which invite disintegration of the soil and a corresponding decline in fertility. We were not driven by necessity into this debauch of our most priceless national resource. No! our profligacy was in truth the child of an abundance which a whole world envied.

In the recent reports of the National Resources Board and the Mississippi Valley Committee[3] this tragic story is told from many angles and in painstaking detail. And the way out is clearly indicated—if there be the will. These documents are not the work of theorists. As to water, the findings are those of a group consisting of five eminent engineers each with outstanding records of achievement—Crocker, Edgerton, Markham, Paul and Woodward; Barrows, perhaps our leading geographer; Person, an economist internationally respected; and Graves, a former U. S. Chief Forester and now dean of Forestry at Yale—assisted by scores of other au-

[3] On October 1, 1934, the Mississippi Valley Committee reported to the Administrator of Public Works on the principles, policies, conditions and problems of the use and control of water in the Mississippi Drainage Area. For the first time the many phases of this subject, such as water supply, hydroelectric power, navigation, irrigation, flood control, low water control and forestry, were brought into common focus and treated in their relation to each other. This report—234 pages and many inserts—can be obtained from the Government Printing Office; price $1.25.

The National Resources Board, Secretary Ickes, Chairman, was created by Executive Order on June 30, 1934. It made a report to the President in five parts on an inventory of national assets and related problems, December 1, 1934. Part I is a summary chapter containing the Board's report and abstracts of four technical subsidiary chapters. The report has 455 pages and many charts and can be obtained from Government Printing Office, price $3.50.

Part III of the National Resources Board report comprises the report of the Water Planning Committee which is a successor agency to the Mississippi Valley Committee, having the same personnel. It contains a brief summary of an inventory of water resources, and statements concerning the principles and policies of the use and control of water resources, together with a group of papers that deal with special aspects of water problems. Obtainable from Government Printing Office, 135 pages and many inserts, price $1.00.

thorities in and out of the Government service. If, as I trust, the engineering profession as a whole, and the American Water Works Association in particular, are to have a vital part in this coming struggle of our country against an impending fate, these documents are worthy of your study.

In an effort to be explicit and therefore helpful—and in so doing to leave out all "ifs, ands and buts," and further to run the risk of being too precise in an area where precision may have no place—it is my personal opinion that as matters now stand and with continuance of the manner in which the soil, the mainstay of individual

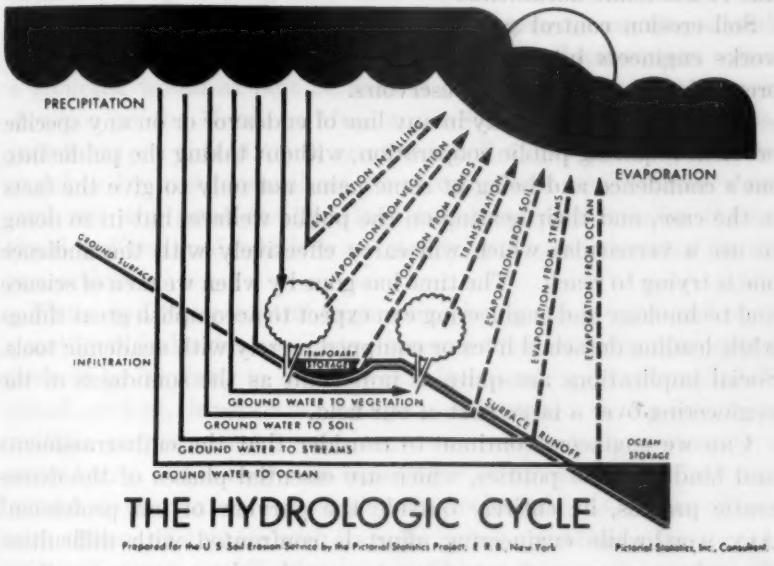


FIG. 1

and collective life, is now being squandered, *this country of ours has left to it less than one hundred years of virile national existence.* And, if that represents a reasonably accurate statement, it is vastly more significant—if we are to win out against the accelerated progression of this gangrenous growth of soil erosion—that we have probably less than twenty years in which to build up the techniques, to recruit the fighting personnel and—most difficult of all—to change the attitudes of millions of people who hold that ownership of land carries with it the right to mistreat, and even to destroy their land, regardless of the effect on the total national estate. For be it remembered that

just as with certain bodily ills—such as tuberculosis and cancer which are only curable in their early stages—so it is with ills to soils built up through hundreds of years. Once ravished beyond a certain point, they are incapable of restoration until after the passage of centuries. "At the present rate of destruction only one hundred and fifty million acres[4] of really fertile land will remain in this country in fifty years."[5] This is the only acreage sufficiently level to resist erosion without some control work. Have it in mind that such approximations of the truth as the above are not considered scientific and therefore are not to be expected in Government or scientific or academic documents.

Soil erosion control surely must make a special appeal to water works engineers interested as they are in serving clear water and preventing the siltation of reservoirs.

One cannot get far today in any line of endeavor or on any specific problem requiring public coöperation, without taking the public into one's confidence and being at some pains not only to give the facts in the case, and their bearing on the public welfare, but in so doing to use a vernacular which will carry effectively with the audience one is trying to reach. The time has gone by when we men of science and technology and engineering can expect to accomplish great things while leading detached lives or equipped merely with academic tools. Social implications are quite as important as the soundness of the engineering over a large part of our field.

Can we engineers continue to consider that the embarrassments and hindrances of politics, which are essential phases of the democratic process, lie entirely outside the purview of our profession? Any worthwhile engineering effort is confronted with difficulties. So perhaps we are going to have to consider the control of politics, as politics affect our work, just as we do the regulation of temperature or the control of quicksands. We cannot detach ourselves from the very frame work of our democratic governmental system.

[4] The total area of the United States is 1,903,000,000 acres, the percentage relationship being 7.9%. The total land area in farms is 986,770,000 acres. The percentage relationship there is 15.2.

The total area of South Dakota, Nebraska and Kansas is almost exactly 150 million acres. The farm land of these three states is approximately 128 million acres. The land area in California is approximately 100 million acres, but the land areas in farms amounts to only thirty millions. The land area of Texas is 168 million acres, with the farm land aggregating 125 million acres.

[5] Quoted from an editorial "Where There Is No Vision" in To-Day, issue April 13, 1935.

The relative incapacity of many experts to help is one of the outstanding facts in the current industrial, economic and social crisis. No matter how narrow the specialty, more and more it becomes important to see it as a part of the whole scheme of things. On another occasion[6] I quoted the late Justice Holmes as saying "Your business as thinkers is to make plainer the way from something to the whole of things; to show the rational connection between your fact and the frame of the universe."[7]

It is to be regretted that we have no generally accepted designation such as "water engineer"[8] in which to include hydrologists, hydraulicians, hydrostaticians, dam-builders, erosion experts, water works engineers, etc. who might as a group give our country a working program for averting the creeping paralysis of soil erosion. Such a grouping would at best be limited in size. But recalling the inscription on the Nordiska Museum in Stockholm, "We are a small nation but we should think great things," might we not yet be led to safety by even a small coterie of competent and devoted water engineers who sense the appalling catastrophe threatening the national welfare, and which is so clearly and closely related to our own activities.

Water and water control engineering has in the past been largely a matter of individual projects—some of them of a size and importance to be inspiring in themselves. But more and more each individual project, irrespective of size and whether it has single or multiple purpose must become only one part or unit or stage in a general plan. It is easy now to note the progression from the building of a single dam on a given river towards the development of that same stream as a whole with its appropriate operating schedule providing for the most efficient use of all the water available. As the sharpness in the line dividing water problems and land problems becomes less acute, planning is extended to an entire drainage area (or basin). When we once grasp the essential identity in all land use, water and erosion problems, wherever they are encountered, one

[6] "The Inspiring Outlook before American Engineering"—a paper given before the Philadelphia Engineers Club, October 19, 1920.

[7] "The Profession of the Law, Conclusion of a lecture delivered to Undergraduates of Harvard University on February 17, 1886." See volume of "Speeches of Oliver Wendell Holmes," p. 23.

[8] In Great Britain there is The Institution of Water Engineers with its publication "Water and Water Engineering."

national—yes, doubtless, inter-national or rather continental—problem emerges. As Thorndike Saville pointed out recently,[9] water planning on the scale here contemplated means passing from the world of construction in which the engineer has always felt at home, into a much more difficult atmosphere, that of farflung policy, statesmanship and creative thinking.

Water engineering as here conceived embraces the small as well as the large, the study of the behavior of water in the little rivulets which begin the destruction of tilled fields as well as the hydraulics involved in harnessing mighty torrents. Recognizing the specialist's ability to broaden our knowledge we know now almost more than we can use about the flow of water in pipes. We need to know more about the flow of water in sheets over the land.[10] There is a highly developed art and science applicable to sizable dams. We need to know more about the function of myriad *small* dams constructed as aids to agriculture, safeguards against soil depletion and the lowering of the water table, and as checks against floods in the streams to which they are tributary, and possibly, as affording evaporation agencies. While data as to the behavior of water in sizable rivers are none too inclusive scientific information about "little waters" is all but non-existent. This latter field has been considered as related to agriculture rather than to engineering. Commercial considerations involved in water supply and power development have given the impetus to the study of the behavior of water in large bodies. Grave social considerations now force on us the study of water as it is progressively ruining our country. In most areas we must seek to revise our present policy of slicking the path of water to the sea. To "hold it"—using an expression from the football field—wherever planning makes holding possible, will, generally speaking, be good national water policy.

Public works will have a constantly increasing importance in the

[9] See "An Inventory and Plan for the Water Resources of the United States" by Thorndike Saville, a paper presented before Metropolitan Section, A. S. C. E., March 20, 1935.

[10] The Soil Erosion Service, now of the Department of Agriculture, is making notable additions to our knowledge in this field. Its researches show that the thick-growing crops, such as grass, clover, lespedeza, etc., are 65 times more effective with respect to soil conservation than are the clean-tilled crops such as cotton and corn grown on the same kind of soil and receiving the same rainfall. The thick-growing crops are also 5 times more effective with respect to sinking rainfall into the ground where it falls than are the clean-tilled crops.

social set-up that may be expected to follow the current political and economic experimentation. If the right to work comes to be recognized to the point where society is willing to provide subsistence for the satisfaction of exigent wants for those not allowed to work, then self-interest, if nothing else, suggests that we provide opportunity for satisfaction of a new stratum of wants by work on publicly owned enterprises in return for the wages to be paid out whether they be subsistence, near subsistence or normal wages. Otherwise we are confronted with the dole and the failure to get that "something for our money" reputed to be so dear to the American heart. Water and water control works are as promising unemployment absorbents as any class of public works.

If public works—as shock-absorbers in periods of depression[11] and as a ready and almost unlimited outlet for labor released through technological advance—are to command wide public support, the tempo of putting such work in process must be materially improved. Democracy must learn how to throw such work into process with a minimum of delay. Constitutional, legal and other retarding influences must be gotten out of the way. During the War destroyers that in normal times remained on the ways many months were launched in seventeen days. We are too apt to use charts indicating the causes of delay as defense mechanisms rather than as guides in cutting out delays. We engineers shall never get on top of this job if we truckle either to politicians, to lawyers or to the 57-varieties of private interests who frequently profit by the seeming inability of public agents to execute tasks in workmanlike fashion.

May we assume that in our national thinking we are about to accept the wisdom of a good sized, and reasonably uniform, annual appropriation for public works[12] to be considered as only one step in a long term—say a twenty year—program which shall include provision for the general improvement of our water resources and most pressing of all, for soil erosion control?

It is obvious that appropriations on any such scale mean not only individual projects numbered in the thousands and including perhaps hundreds of engineering enterprises in a program requiring possibly many years for their completion, but they also mean a break with

[11] Stuart Chase says public works must take the place of "the fly-wheel of capitalism" in "Old Man River"—a sympathetic review of the Mississippi Valley Committee Report in the New Republic for March 27, 1935.

[12] This technique of budgeting and visualization is in no wise dependent on any particular sum to be appropriated.

hitherto known types of administrative and legislative control. If the Congress adheres to past practice it will be so bogged down with detail as to make impossible what is really vital in its directive control. An entirely new capital outlay budgetary practice for the nation[13] is demanded. After all, democracy and the techniques through which it works are relatively new things in the world. Any assumption that whatever *is* is necessarily sacrosanct, and not open to review, is a dis-service to our institutions.

In order to see how such large scale annual appropriations may influence planning for water use and control, and to visualize the specific engineering projects through which it is to be carried out, the country can be divided into its constituent drainage areas and regions. For our immediate purpose division into twelve master regions will suffice, as shown on figure 2. For each such drainage region the monies to be available can be spread over the twenty year period and allocated as between classes of expenditure, as shown on one scale for the North Pacific drainage area on figure 3, and on a somewhat reduced scale, on figure 4.

It is wholly feasible to portray on separate sheets, in identical fashion, the expenditures proposed for each of the drainage areas constituting the master region. This presentation of detail may proceed as far as considered desirable.

The allocations broadly correspond with the varying needs of each of the regions. These diagrams, and those which follow, are of course schematic only and are intended to illustrate one method of that visualization without which no such plan stands a chance of adoption. Without access to records and plans of individual departments it would have been futile to attempt even to approximate allocations as between many specific objects of expenditure.

Both soil erosion and forestry outlays have been omitted from the foregoing charts because in the present state of our thinking both are usually classed as land as contrasted with water activities. But any exclusion in practice of reforestation and soil erosion control from a comprehensive water conservation program would be criminal. Water works engineers will readily agree because on the watersheds of many municipal plants both reforestation and erosion control are now recognized activities.

[13] For a discussion of the comparable problem of a long range municipal capital budget see "Our Cities Awake"—Doubleday, Page & Co. Page 332.

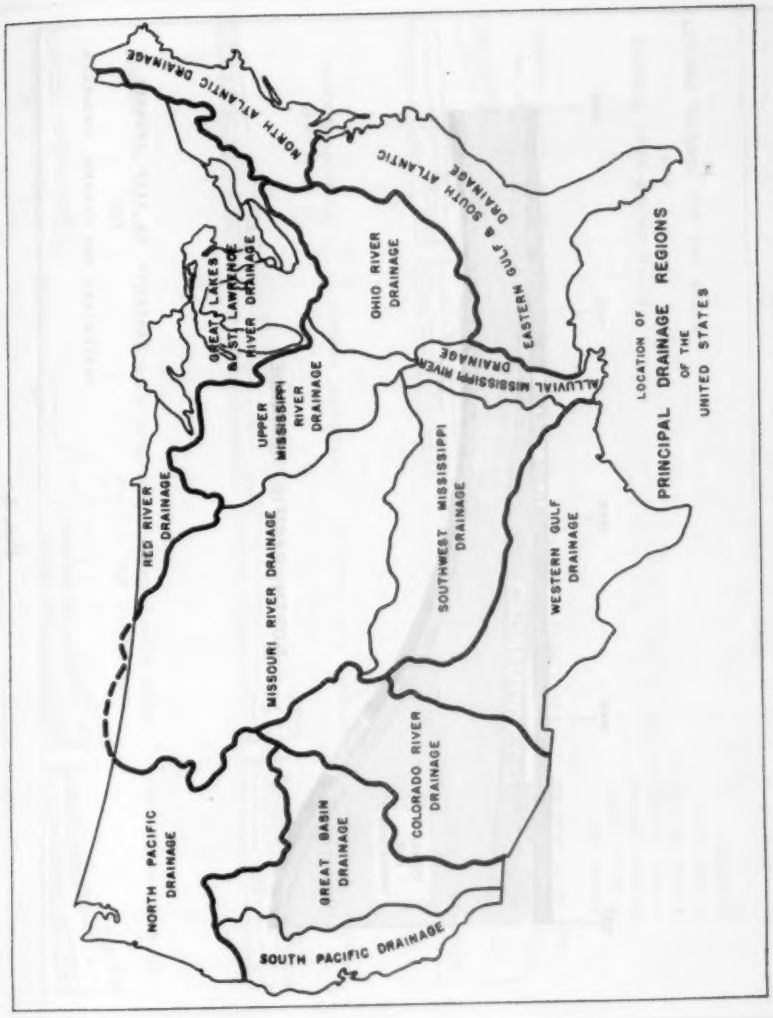

NORTH ATLANTIC DRAINAGE
SOUTH ATLANTIC & GULF EASTERN DRAINAGE
GREAT LAKES & ST. LAWRENCE RIVER DRAINAGE
OHIO RIVER DRAINAGE
ALLUVIAL MISSISSIPPI RIVER DRAINAGE
UPPER MISSISSIPPI RIVER DRAINAGE
RED RIVER DRAINAGE
MISSOURI RIVER DRAINAGE
SOUTHWEST MISSISSIPPI DRAINAGE
WESTERN GULF DRAINAGE
COLORADO RIVER DRAINAGE
GREAT BASIN DRAINAGE
NORTH PACIFIC DRAINAGE
SOUTH PACIFIC DRAINAGE
LOCATION OF PRINCIPAL DRAINAGE REGIONS OF THE UNITED STATES

FIG. 2

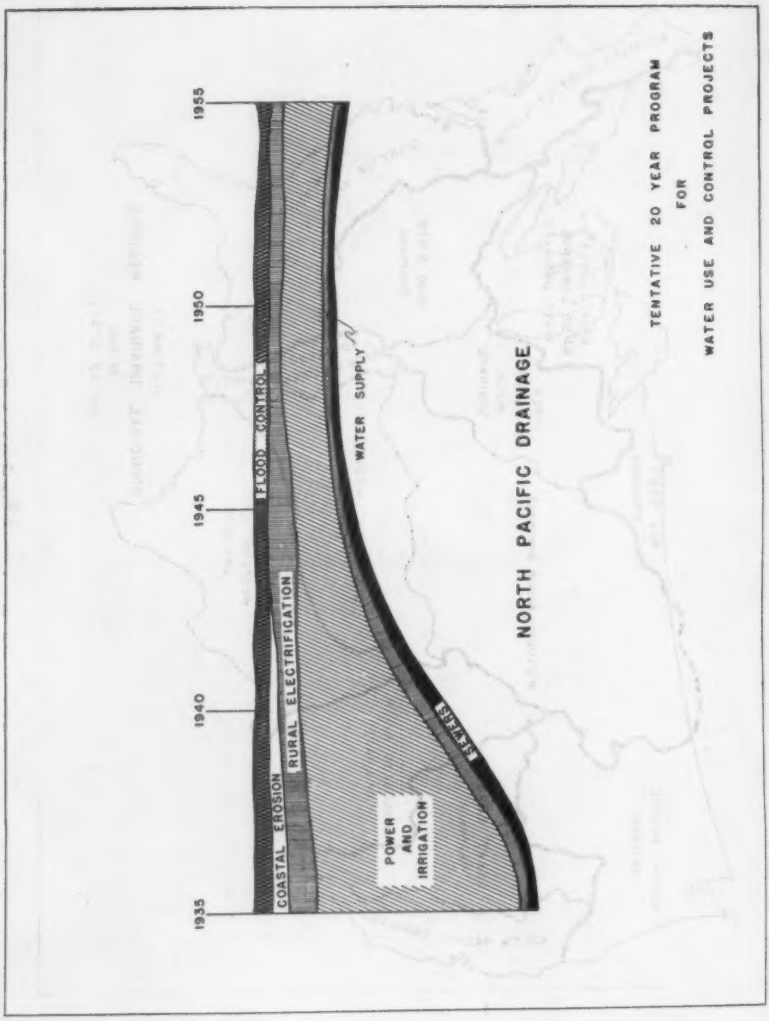

1955
1950
1945
1940
1935
FLOOD CONTROL
WATER SUPPLY
COASTAL EROSION
RURAL ELECTRIFICATION
POWER AND IRRIGATION
NAVIGATION
NORTH PACIFIC DRAINAGE
TENTATIVE 20 YEAR PROGRAM
FOR
WATER USE AND CONTROL PROJECTS

FIG. 3

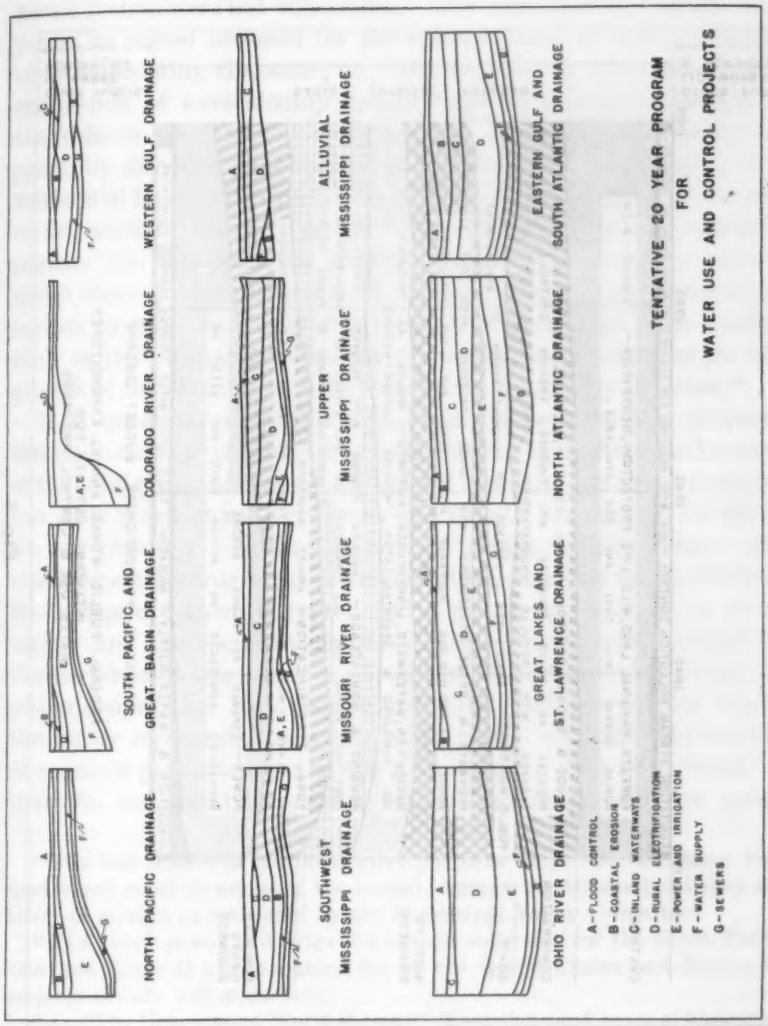

NORTH PACIFIC DRAINAGE
SOUTH PACIFIC AND GREAT BASIN DRAINAGE
COLORADO RIVER DRAINAGE
WESTERN GULF DRAINAGE
SOUTHWEST MISSISSIPPI DRAINAGE
MISSOURI RIVER DRAINAGE
UPPER MISSISSIPPI DRAINAGE
ALLUVIAL MISSISSIPPI DRAINAGE
OHIO RIVER DRAINAGE
GREAT LAKES AND ST. LAWRENCE DRAINAGE
NORTH ATLANTIC DRAINAGE
EASTERN GULF AND SOUTH ATLANTIC DRAINAGE
A-FLOOD CONTROL
B-COASTAL EROSION
C-INLAND WATERWAYS
D-RURAL ELECTRIFIGATION
E-POWER AND IRRIGATION
F-WATER SUPPLY
G-SEWERS
TENTATIVE 20 YEAR PROGRAM FOR WATER USE AND CONTROL PROJECTS

FIG. 4

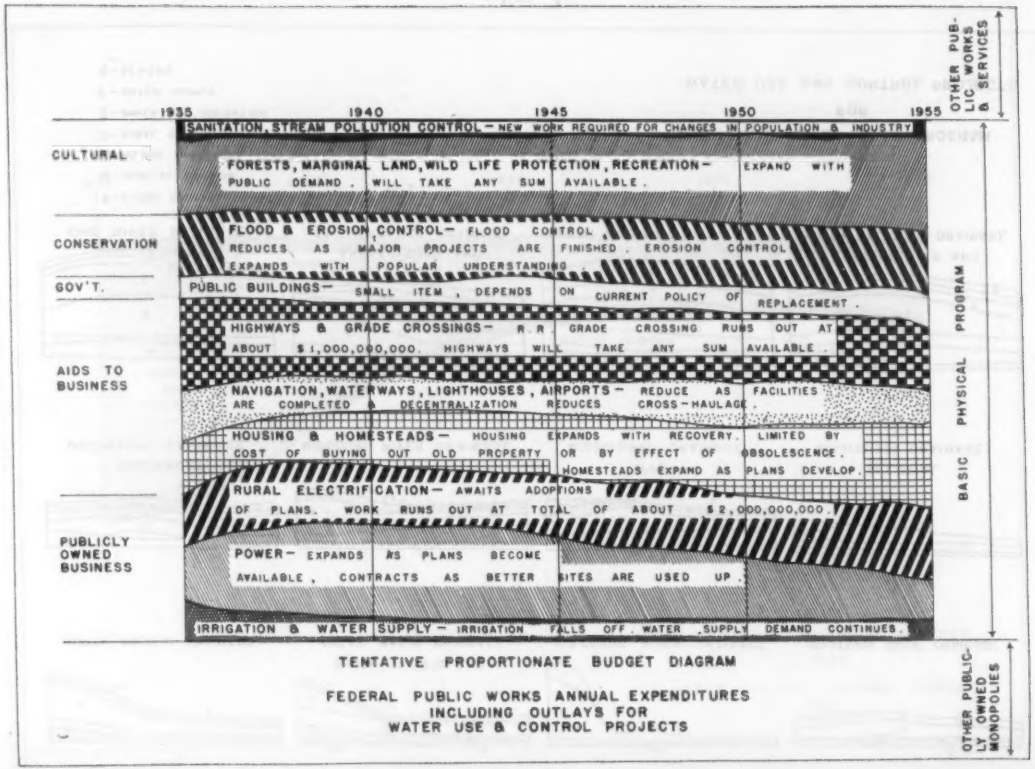

1935
1940
1945
1950
1955
OTHER PUBLIC WORKS & SERVICES
SANITATION, STREAM POLLUTION CONTROL — NEW WORK REQUIRED FOR CHANGES IN POPULATION & INDUSTRY
CULTURAL
FORESTS, MARGINAL LAND, WILD LIFE PROTECTION, RECREATION — EXPAND WITH PUBLIC DEMAND. WILL TAKE ANY SUM AVAILABLE.
CONSERVATION
FLOOD & EROSION CONTROL — FLOOD CONTROL REDUCES AS MAJOR PROJECTS ARE FINISHED. EROSION CONTROL EXPANDS WITH POPULAR UNDERSTANDING.
GOV'T.
PUBLIC BUILDINGS — SMALL ITEM, DEPENDS ON CURRENT POLICY OF REPLACEMENT.
HIGHWAYS & GRADE CROSSINGS — R.R. GRADE CROSSING RUNS OUT AT ABOUT $1,000,000,000. HIGHWAYS WILL TAKE ANY SUM AVAILABLE.
AIDS TO BUSINESS
NAVIGATION, WATERWAYS, LIGHTHOUSES, AIRPORTS — REDUCE AS FACILITIES ARE COMPLETED & DECENTRALIZATION REDUCES CROSS-HAULAGE.
HOUSING & HOMESTEADS — HOUSING EXPANDS WITH RECOVERY. LIMITED BY COST OF BUYING OUT OLD PROPERTY OR BY EFFECT OF OBSOLESCENCE. HOMESTEADS EXPAND AS PLANS DEVELOP
RURAL ELECTRIFICATION — AWAITS ADOPTIONS OF PLANS. WORK RUNS OUT AT TOTAL OF ABOUT $2,000,000,000.
PUBLICLY OWNED BUSINESS
POWER — EXPANDS AS PLANS BECOME AVAILABLE, CONTRACTS AS BETTER SITES ARE USED UP.
IRRIGATION & WATER SUPPLY — IRRIGATION FALLS OFF. WATER SUPPLY DEMAND CONTINUES.
BASIC PHYSICAL PROGRAM
OTHER PUBLICLY OWNED MONOPOLIES
TENTATIVE PROPORTIONATE BUDGET DIAGRAM
FEDERAL PUBLIC WORKS ANNUAL EXPENDITURES
INCLUDING OUTLAYS FOR
WATER USE & CONTROL PROJECTS

FIG. 5

A hypothetical composite record of a basic physical program of 500 millions[14] annually as spread over a twenty year period is shown on figure 5. Additional expenditures required for adjusting the economic system were not considered. The variations in volume from period to period assumed for the several classes of work are rather of an engineering character, i.e., time required to make plans, early completion of work already started,[15] and the definite limitation on the volume available of certain kinds of work. For indeed one promptly discovers that current ideas as to what constitutes public works will have to be expanded radically if expenditures at the rate of 500 millions annually are to be continued for any considerable period. On this chart has been illustrated one of the many ways in which there can be shown a mass of explanatory detail, as found on certain educational charts illustrating how even large scale matters such as the comparative history of peoples and even the origin and growth of the evolutionary process can be graphically depicted.[16]

It is necessary now to see the relation between this proposed 500 million dollar annual public works outlay against the background of the total national income, not only of course as it is at the moment, but as it possibly will be, during the twenty year period for which we are planning. Naturally, no two people see the future—and this is especially true of the economic future—in quite the same terms. So on figure 6 there is reproduced a picture of one way in which society and the social income may possibly evolve as pictured for the purposes of this paper by Engineer David Cushman Coyle, for whose coöperation I am deeply grateful. The heavy black line in the center represents the public works item. Considerable latitude of course is permitted in drafting such a chart. The only "must" is that the net social income be raised from its present low point,

[14] The sum chosen is for illustrative purposes only. But the figure here used is not much in excess of the annual losses in the Mississippi Valley due solely to erosion as estimated by the Mississippi Valley Committee.

[15] The heavy power and irrigation outlays suggested for the North Pacific area (see figure 3) are accounted for by the Grand Coulee and Bonneville projects already well under way.

[16] a. "The Histomap of World History" (Four thousand years of history on a single page)—unfolded size 13" wide by 5'3" long.

b. "The Histomap of Evolution"—(Ten thousand million years of evolution on a single page)—unfolded size 22" wide by 4'10" long.

Both charts arranged by John B. Sparks, and distributed by Rand McNally & Company, Chicago.

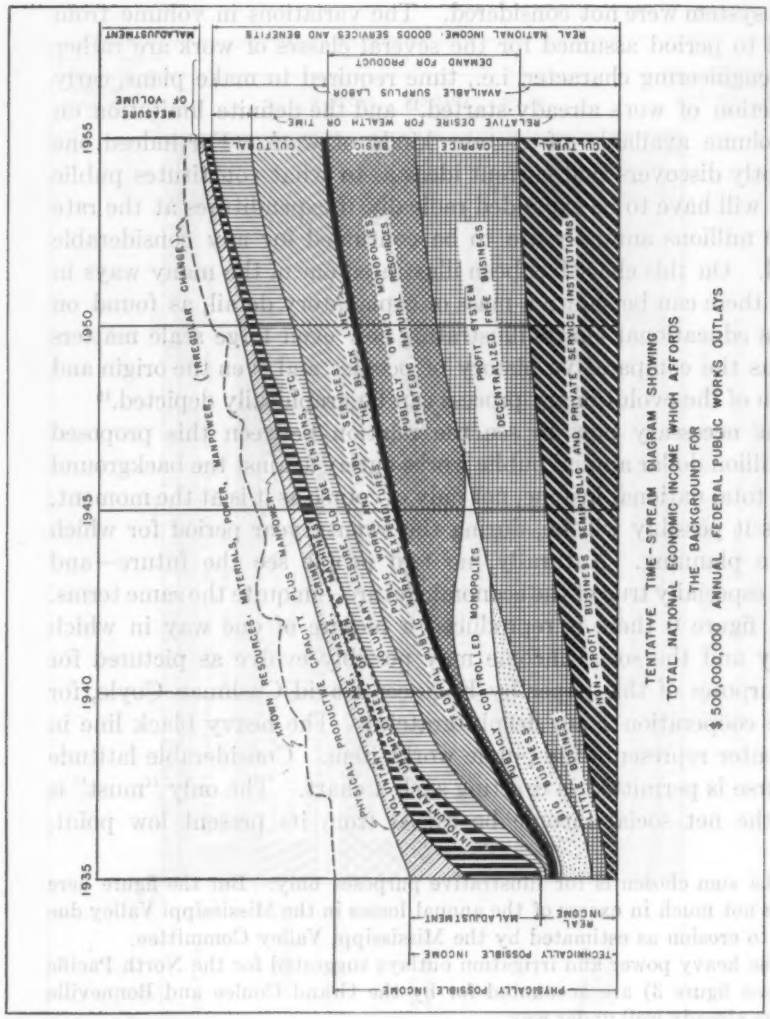


FIG. 6. The black line crossing about midway on the chart represents the suggested half-billion annual public works expenditure. Drawn to the actual scale of the chart this line is hardly visible. So to assist the reader it has been made nearly ten times as wide as it should be.

relative to what is potential, to one in which the amount required for public works will be a relatively small percentage of the total. One notes that even a modest cut in the part of the national income here allocated to "crime" would provide the means for a fully adequate water and soil conservation program.

Assuming that expenditures on the grand scale for water use and control capital outlays will be initiated under the Work-Relief Act and continued under successor agencies it will become necessary for efficient operation to arrange them in an administrative budget in some such graphical form as here suggested. To have these programs reviewed by the Congress say at five year periods—and not all of them in the same year—might prove a workable scheme.

Unless we can cope quickly and competently with soil erosion and its related water problems, our most prized national possessions will gradually lose their significance—our political institutions, our struggle for justice and equality of opportunity, even liberty itself. And so will pass also the opportunity for the high undreamt Adventure for which we Americans have been laying the foundations. As the average yield of our soil goes down the morale of the people also will ebb. And ours will follow the history of scores of civilizations that have risen and flourished and disappeared. The acres—dead acres—will still be here mute monuments to the folly of the educated man.

Richly endowed by nature this people has gone forward under free institutions to higher standards of living than the race has heretofore enjoyed. What a devastating tragedy it would be to have our national progress thwarted now by the failing of fertility of our agricultural lands just as we begin to realize the implications of the power age and the economy of plenty.

To accomplish this high purpose of saving our soils, and thereby our civilization, we need competent and bold planning,[17] adequate spending, and a spirit of high devotion. Who will lead if the engineers fail to accept this challenge?

[17] With hundreds of millions available for allocation and our agricultural lands facing relatively quick depletion projects in the water field are demanded comparable in imagination and boldness with the aeronautical engineers' plan to use the stratosphere.

DEFICIENCIES IN PRESENT WATER RESOURCES INFORMATION

By Thorndike Saville

(Associate Dean and Professor of Hydraulic and Sanitary Engineering, New York University; Consultant, Water Resources Section, National Resources Board, Washington, D. C.)

The late Justice Holmes in one of his last great opinions said "A river is more than an amenity; it is a treasure. It offers a necessity of life that must be rationed among those who have power over it." This pronouncement, which has already become famous, may equally well be applied to the water resources of the entire nation. Water, in the atmosphere, on the surface of the earth, or underground, is the greatest mineral treasure which this, or any, country possesses. Although it is a renewable treasure, it is neither limitless in amount nor distributed equally throughout the country, nor susceptible of complete control by man.

While the inexorable operations of the hydrologic cycle have been recognized for thousands of years, and are expressed in the passage from Ecclesiastes that "All the rivers run into the sea, yet the sea is not full; unto the place from whence the rivers come thence they return again," still the ever continuing processes of precipitation, percolation, run-off, and evaporation are neither uniform in amount nor (within narrow limits) predictable as to quantity or time of occurrence.

The character of our civilization, the development of our agriculture and industry, the welfare and safety of our people everywhere is governed more by the nature and extent of water resources than by any other factor. To plan intelligently for the development, conservation, and control of this great national treasure for its most beneficial public use is certainly one of the highest services which the engineer can render.

The uses of water resources have been classified in the order of their influence upon man as follows:[1]

[1] Zimmerman and others. See World Resources and Industry. E. W. Zimmerman. Harpers, 1933.

1. Atmospheric moisture indispensable to organic life.
2. Drinking water for man.
3. Water used in agriculture and animal husbandry.
4. Water as the habitat of fish and sea food.
5. Water used for the generation of power, both hydroelectricity and steam.
6. Water used for mechanical and chemical processes in industry.
7. Water as a medium of transportation.
8. Water in its effect on human settlement, especially the location of cities.
9. Water as a medium for the removal and purification of wastes.
10. Water as a recreational asset.
11. Water as a determinant of political boundaries.
12. Water used as ice.

This enumeration of the chief uses of water immediately suggests two major conclusions.

1. In any given populated region or locality, one or more of these uses is likely to be in conflict with another, and whenever the pressure of civilization upon the water resources approaches a point where no surplus water exists sufficient for all of the desired uses, a determination as to relative priorities for certain uses must be made. On the other hand, surplus waters require control. Planning for use and control is clearly indicated.

2. To plan for use and control, even on limited local areas, requires factual data of a scientific or technical nature. The more widespread the region for which planning is required, the more detailed and elaborate the scientific and technical background must be. This involves an inventory of the water resources, and it must precede any adequate planning for most beneficial use and control.

In January, 1935, two significant reports appeared in which for the first time in the history of this country an effort has been made to view the water resources of the nation in relation to their multiple uses and from the two aspects of an inventory and a plan just mentioned. These reports are those of the Mississippi Valley Committee, and of the Water Planning Committee of the National Resources Board.[2] They have been widely referred to in the press, and have

[2] The membership of these Committees was as follows: Messrs. H. H. Barrows, H. S. Crocker, Glen E. Edgerton, Henry S. Graves, Edward M. Markham, C. H. Paul, H. S. Person, S. M. Woodward, and Morris L. Cooke, Chairman.

been reviewed in the Journal of this Association and in an excellent series of abstracts appearing in Water Works Engineering. They are worthy of the thoughtful consideration of every water engineer.

RECONCILING MULTIPLE USES

What in brief do these two comprehensive and profusely illustrated reports point out that is of immediate concern to us? In the first place most of you have read of, and many of you have experienced, the effects of the great drought last year which caused such human suffering, and monetary loss, in the central States from the Dakotas southward. All of us will be affected by it in increased prices of foods if in no other way. It is a striking illustration of how water resources is no longer a local problem, but one of national scope. For several years rainfall has not only been deficient in the region mentioned, but such precipitation as has occurred has not come at the best time for crops.

In much of the vast agricultural and stock raising region west of the 100th Meridian precipitation is either insufficient for the needs of the uses to which the land has been put, or it does not come at the right time, or both. Hence, for full land utilization the water of rivers must either be stored in reservoirs in times of surplus flow for delivery in times of deficient rainfall, or it must be stored by percolation into the great natural reservoirs of the soil in what we call ground water from which it may be pumped in time of need. If precipitation is deficient for several successive years, the surface reservoirs, unless carefully planned with this objective in view, may be insufficient, or the ground water levels may be so lowered as to cause wells to go dry, or to increase pumping costs to an uneconomical point. As ground water levels are reduced, as soil moisture disappears, as crops fail, as the tilled land becomes moistureless and barren, dry winds take up the very earth itself and over large areas the former fertile places may be for decades or perhaps forever removed from human use.

You may see, therefore, that planning for water use cannot be removed from planning for land use. To plan effectively for use of water with relation to land means that we must evaluate various possible uses of water and of land.

Let us take another example from the more humid industrial regions of the east. We have a great river, say, the Ohio. Its flow is utilized for domestic water supply, for removing sewage and industrial wastes, for water used in manufacturing purposes, for production

of hydro-electric power, and for navigation. From time to time droughts occur which seriously deplete the flow causing not only danger to human activities from deficiency of water, but great impairment of water quality and consequent injury to industry, and perhaps to health. On the other hand, occasionally great floods occur, causing millions of dollars loss both in direct property and health damage, and in indirect damage from interruption of transportation facilities and the numerous activities dependent thereon. The soils are eroded, fertility is lost, and reservoirs and river channels become silted.

In such a river, what might a well planned reservoir or series of reservoirs do? Obviously, the flood waters would be retarded, and could be let down during periods of low flow producing greater supply for domestic use, greater depth for navigation, greater dilution of wastes, and production of power. A lock may be placed in the dam in the interest of navigation, and a power house for the generation of electricity. But all of these uses are not complementary. To be most effective for flood control a reservoir should be empty when the flood comes. To be most effective for low water control, a reservoir should be full as much of the time as possible. If the reservoir is not to fill up with silt and lose its utility, erosion control measures must be invoked, though such measures are essential in any event in the interests of soil conservation. The degree to which the river may be used as a carrier of wastes without polluting it beyond the ability of water purification plants to deliver a safe water to the public is a matter calling for scientific study and careful river regulation. It is apparent that the maximum utility of many of our rivers in the more densely populated regions requires the highest degree of planning to evaluate properly their multiple uses to the greatest public benefit.

Turn now to our coasts. How often do we think of the numerous factors at work to impair the utility of our harbors, sounds, and beaches. Silt from eroded farms tend to fill up some of our harbors and injures shellfish areas; pollution from our seaboard cities makes certain of our coastal waters unfit for bathing; the ocean waves and currents destroy or damage millions of dollars worth of property by erosion of the sandy beaches. Inlets are opened or closed with resultant effects upon the fishing and shellfish industry. Here again we must plan for these conflicting uses of coastal waters, controlling pollution and erosion where it is in the long run the economical thing to do in the interest of the national welfare.

Various other aspects of water resources use and control are important, including those of recreation and the provision of suitable environment for aquatic life. On interstate and international water problems volumes could be written, and in the reports referred to some of the more serious complications of this kind are discussed.

Some of you may think, all of this is interesting in a sort of academic way, but what we are concerned with as practical water works men is in the great majority of cases a relatively local problem. We are chiefly interested in delivering a safe and adequate supply of water to our own community. But I say to you it has happened that what may be a purely local problem today will become a regional problem tomorrow. In water supply perhaps even more than in certain other matters, no community lives only to itself. The necessity to allocate and plan for water use and control is rapidly being forced upon the attention of even the smallest community. There are too many demands pressing upon our limited water resources to permit any of us to concern ourselves much longer with any single aspect of water use.

PRECIPITATION

Much has been written in the Journal of this Association and in the technical and lay press about the effects of recent deficiencies in precipitation upon public water supplies. All of you will readily agree that accurate information with respect to precipitation is necessary in the planning and development of public water supplies. One might assume that with some 4,500 precipitation stations we should be able to collect most of the essential data needed. But such is not the case, although precipitation records are more nearly adequate and are available for considerably longer periods than any other class of hydrological data. Only about 200 of these precipitation stations are equipped with recording gauges, essential to studies of rainfall intensity and relation between rainfall, run-off, and ground water levels. On a square mile basis, we have fewer precipitation stations than many foreign countries, even than some so-called backward regions such as India. We are particularly deficient in precipitation data from high altitudes which serve as collecting grounds for much of the surface and sub-surface flow. No careful study has ever been made of the need for additional precipitation stations in specific parts of the United States with particular reference to water supply investigations.

Most of the precipitation stations are operated by voluntary ob-

servers: As a result there are frequently defects in the records due to (a) unsatisfactory exposure of gages, (b) lack of uniformity in time of making observations, (c) changes in location of gages during record period, (d) interruptions in continuity of record due to absence or carelessness of observer, etc.

Records of intensity of precipitation for less than twenty-four hour periods are not readily available in published form. Numerous precipitation observations made by municipal water authorities, power companies, and others are not published at all, or are published only in annual reports not readily available, or are not collected or published in approved form. Several specific recommendations as to improvements in precipitation data for water supply may be suggested as follows:

1. Location of additional stations after a study to indicate areas having inadequate data, particularly in the southwest and at higher elevations.

2. Increase in the number of stations equipped with recording gages.

3. Efforts at standardization of times of making observations; improved training of voluntary observers; more frequent inspection of coöperative stations.

4. Critical review of records published to date, with indications of significant changes in location, exposure, and other influences affecting accuracy of record.

5. Inauguration of a program for publication by the U. S. Weather Bureau of all rainfall data being currently collected, whether directly under its auspices or by other agencies.

STREAM FLOW

None are more aware than the members of this Association of the highly variable characteristics of stream flow and the essentially local phenomena connected with the flow from relatively small drainage areas. The U. S. Geological Survey has standardized both the collection and publication of stream flow data collected at nearly 3,000 gaging stations operated by or in coöperation with it. However, many more such stations are needed, particularly on the smaller streams, especially those likely to be used for public water supply purposes. The larger streams of the country are fairly well covered by gaging stations, except that continuous long term records are deficient in certain localities, especially upon the Mississippi and some

of its larger tributaries, notably the Canadian, Cimarron, Red, and Arkansas Rivers.

No federal agency has attempted the publication of summaries of stream flow data analogous to the climatological summaries of the Weather Bureau. It would be most helpful in studies of water supply problems if a compilation of stream flow records could be issued, with corrections to numerous old published data which later observations have shown to be in need of revision. There should be included those records collected by other agencies which conform to reasonable standards of accuracy. A few states, notably California, New Jersey, Connecticut, North Carolina, and Tennessee, have within recent years issued summaries of the character indicated.

One serious difficulty which should engage the attention of members of this Association has to do with maintenance of existing gaging stations. Continuity of record is of the utmost importance, and a record of even ten years in length is of far less value than one over thirty or fifty years long. The great majority of gaging stations are operated by the U. S. Geological Survey in coöperation with local agencies and under present law such agencies must pay 50 percent of the annual costs. All sorts of financial difficulties attendant upon the recent depression have caused many states, municipalities and other agencies to cease their coöperation. The result seems likely to be extremely serious in that numerous important stations have had to be abandoned, and others are likely to be. The interruption of a good record for even a year is not to be lightly regarded with respect to future important uses to be made of these data. While the basic principle of local coöperation appears sound, and should be continued, it does seem that the expenditure of federal emergency relief funds for the work for the next year or two to keep good stream flow stations in continuous operation is thoroughly justified in the national interest in basic water resources data. A reasonable number of base stations should be selected for continuous operation by the Geological Survey irrespective of any local contribution. A minimum of well located long term record stations is essential to any adequate program of water resources use and control. The collection and publication of such fundamental data should not be subject to the whims of local expediency or of state legislatures.

EVAPORATION

In its Inventory of Water Resources, the Water Resources Section of the National Resources Board prepared maps showing the general

distribution of average annual precipitation and run-off over the United States. It proposed to do the same for evaporation, but had to abandon the attempt because the data were so evidently inadequate. There are only about 100 evaporation stations equipped with water pans in the entire country, and over 90 percent of these are located west of the Mississippi River. Many are not of a standard type, and few have been in operation as long as twenty years. It is astonishing how little we really know about evaporation from water surfaces, and the factors that modify it. Evaporation, unlike precipitation and run-off, is an invisible phenomenon. None the less it represents an important factor in most water projects and one which the hydrologists and engineers concerned with water supply have generally neglected to investigate adequately.

The U. S. Weather Bureau should be supported in a request for funds to locate many more standard evaporation stations and to publish the data therefrom, and also those from evaporation stations operated by other agencies. Further studies are needed upon the relation of evaporation from pans to that from open water surfaces, and upon the effect of various factors which influence evaporation.

SNOW SURVEYS

This is a hydrological factor related to precipitation, evaporation, and stream flow, previously discussed. It is of relatively recent application to water supply engineering, not because of any change in practice, but because water supply engineers had never realized its great potentialities until they were demonstrated by a meteorologist, Professor J. E. Church of the University of Nevada Agricultural Experiment Station. Less than ten years experience with snow surveys in several western states, particularly Nevada, Utah, Washington, and California indicate that, in conjunction with properly located stream gaging stations, snow survey methods are capable of giving reliable forecasts of future surface run-off. Coöperative arrangements between several state and federal agencies in these western states have been seriously handicapped by lack of funds and absence of any federal program or responsibility. This most recent tool of the water engineer is of the greatest promise. Results already have demonstrated its great practical value, and its applications have yet to be thoroughly explored. There is definitely needed the sponsorship of an appropriate agency or agencies of the federal government to plan and carry out immediately a comprehensive program of snow surveying on a national scale and in coöperation with state and local

authorities. In the mountainous and headwater regions of the west and the northwest snow surveying should be promptly organized under federal auspices, and the results made available to water engineers as aids in forecasting stream flow and in interpreting many other hydrological phenomena.

GROUND WATER

Although the Water Resources Branch of the U. S. Geological Survey has had a Ground Water Division for many years, hydrologists and water supply engineers have only recently begun to realize the full significance of ground water with relation to many major water supply problems. Constituting the source of public water supply for over half the population of the United States; serving as the principal or sole source of low water flow to rivers and lakes; affecting in an important way the character of agricultural practice and of land uses; the relations between ground water and other hydrological factors has been all too little explored. Only now are we beginning to acquire knowledge of our ground waters, as to their extent, depth, fluctuations, and quality, which seems to promise much for increased utility in the development, control and forecasting of water use.

Only one or two states have any well-conceived plan for investigating their ground water supplies. Even in regions where ground water has always been the chief source of domestic or irrigation supply, relatively little continuous scientific data has been collected in systematic fashion. Have ground water levels dropped in a given region? If so, how much during the past 20 years? Is the cause merely deficiency in precipitation or excessive draft by vegetation (through irrigation possibly), or for public or industrial water supply? If so, is the draft in excess of recharge by precipitation? Can the underground reservoirs be economically replenished through such practices as "water spreading," decentralized reservoirs, or otherwise? Is the chemical quality of the ground water deteriorating with decline in water level? At what horizons may water of best quality be obtained? All of these and many other vitally important questions cannot be answered in most of the important ground water areas of the United States. We have adopted no such comprehensive program for collecting ground water data as we have for precipitation and surface waters. It is again a case of out of sight, out of mind.

One of the important recommendations of the Water Resources Section of the National Resources Board was that for the inaugura-

tion of a well considered program for the continuous and systematic collection of basic data with respect to our ground water resources. Such a program should receive the hearty endorsement of this Association.

CHEMICAL AND PHYSICAL QUALITY OF WATER

In an illuminating chapter on this subject in the report of the Water Resources Section of the National Resources Board, Sheppard T. Powell, a member of this Association, has presented striking evidence of the effect of water quality upon the cost of water used by both domestic and industrial consumers. He has shown, as perhaps an extreme instance, how increased concentration of chemical substances in the Delaware River water, resulting from decreased stream flow, imposed a financial burden on industry and domestic consumers of nearly seven million dollars between 1929 and 1933.

The chemical quality of surface and ground waters is of marked importance, both from the standpoint of domestic and industrial use. Water softening and iron and manganese removal affect not only the design and operation of public water treatment plants, but the requirements of industry for boiler and process water free from appreciable quantities of dissolved mineral substances imposes annually a large financial burden. The amount and character of the silt carried in and by the streams is of economic importance to the water engineer. It requires chemicals and basins for its removal, and it reduces the storage capacity of reservoirs.

No systematic attempt has ever been made to collect data on the quality of the surface and ground waters of the country. Thousands of isolated analyses are available, but when uncoördinated with stream flow or with depth and geological character of ground water horizons, such sporadic analyses are frequently of little value and may be misleading. Great gaps appear on the maps of the United States showing average hardness of water because of lack of data. In the entire Mississippi Valley, comprising some 40 percent of the area of the country, and including all or parts of 31 states, there are not (if we exclude Illinois and Kansas) more than 25 reliable water analyses based on observations carried on over a year or more.

You gentlemen of the water works fraternity ought to be more concerned than you are with the orderly collection of data relating to the chemical quality of our waters. This particular element of water resources information is of more specific interest to you than to

any other group. Again a national program of data collecting and publication under appropriate federal auspices seems called for.

COLLECTION, PUBLICATION AND ANALYSIS OF BASIC WATER RESOURCES DATA

It should be apparent, and no doubt has been long recognized by many of you, that there is a great dearth of accurate basic data with respect to perhaps our greatest national treasure, our water resources. Good beginnings have been made; the responsible state, federal and many municipal agencies have recognized the need;—why then have we not done and why are we not doing more? To the writer the answer is threefold: Program, Coördination, and Support.

Program

There must be a definite and continuing program for the comprehensive investigation of our water resources. This should mean collection and publication of basic data in a form readily available for the use of water engineers and others. Neither the Congress nor the States have as yet adopted any such clean cut policy. An important beginning has been made in the reports of the Mississippi Valley Committee, and of the Water Planning Committee of the National Resources Board. Guiding principles of a directive nature are there set forth. The execution of this program, its modification and improvement as conditions change and more knowledge becomes available, can only be achieved by the active interest and continuing collaboration of organizations such as this Association.

Coördination

Hitherto a serious handicap to an effective program has been lack of coördination, as between various Federal agencies and between federal and state agencies. There is also a lack of agreement on standards for collection and publication of hydrological data. A large amount of data have been collected by federal, state, and municipal agencies which are of little value, either because they were collected by poor methods and are not accurate, or were not published, or if published are not generally or readily available. A central coördinating agency under federal auspices could be most helpful in this lamentable but remediable situation. There may be no necessity to curtail reasonable data collecting activities of the various agencies, but there is great need to move cautiously toward greater

uniformity of procedures and to centralize publication. No new bureaucracy is necessary or desirable, but an effective coördinating agency seems essential.[3]

Support

No program as little spectacular and as long continued as collection of basic water resources information can remain effective without constant support by those benefiting from it. It is easy for those of us who are experienced in hydrological investigations to criticize the personnel, procedures, and ability of those federal and state agencies seeking to collect basic water resources data for our use. I suppose that in this, as in other matters, we receive in just about the measure that we contribute. If we feel that present policies are unsatisfactory, we should seek to have them remedied. But we will get nowhere by individual "grousing." Get an energetic committee to work, decide what is wanted, and the committee with the support of this and similar organizations can get from public agencies just about what it wishes.

Conceive, promote, or endorse an adequate national program. See that it involves adequate and appropriate coördination of effort. Then support it—keep the agencies you endorse on their toes by constructive criticism—move for their change when change is demonstrably needed—but support by persistent and continuous organized effort the appropriate agencies through pressure for adequate funds, efficient personnel, and effective procedures.

ANALYSIS OF BASIC DATA

The collection and publication of basic hydrological data according to a national program can be carried on effectively only by federal and state agencies. Many feel that the functions of these agencies should stop there; that the analysis and interpretation of such data are the function of the practicing engineer or specialist. In general, the writer believes this to be a sound and desirable rule. But there are exceptions. There are more and more water resources problems of great importance which, if they are solved at all, must be solved by

[3] A promising step in this direction has been taken (April, 1935) under the auspices of the Water Resources Section of the National Resources Board by the appointment of an Advisory Committee on Standards and Specifications for Hydrological Data consisting of four representatives of federal agencies and four hydraulic engineers.

a federal or state agency. No individual, no municipality, indeed no state, would be likely to undertake a detailed technical study of all factors relating to the drought in the central states. No such agency would be likely to undertake studies on a scale as comprehensive as those shortly to be made available on Flood Flows in the United States, and on Rainfall, Run-off, and Ground Water Relations. These have been undertaken by the U. S. Geological Survey in collaboration with the Mississippi Valley Committee and with the advice of committees of experts from the American Society of Civil Engineers and the American Geophysical Union. There are certain large scale hydrological investigations of regional or national import which can be effectively pursued only under federal or state auspices. This Association might well give thought to important fields of hydrological research having regional or national implications, and promote their prosecution by appropriate federal agencies in coöperation with advisory groups from this and other technical organizations.

The first requisite for any sound planning of water use must be accurate hydrological information. The inventory section of the report of the Water Planning Committee presents for the first time a brief but coördinated picture of our present knowledge of precipitation, runoff, ground water, evaporation, water quality, and coastal waters for the country as a whole. It portrays the extent to which our waters have been used for public and industrial water supply, power, navigation, wastes removal, irrigation, and recreation. It indicates the problems of flood control and drainage. It makes clearly apparent how deficient we are in exact or adequate knowledge regarding so much of this fundamental data. For this reason, it is imperative that we begin at once a far more comprehensive and scientific approach to the investigation of our water resources, involving particularly standardized and coördinated procedures for the collection compilation, and publication of basic hydrological information.

If we will earnestly promote and effectuate the absolutely necessary scientific and engineering study of our water and land problems; if we will make use of the existing and new data to plan intelligently for the most beneficial use of our water and land resources; we may then be assured that, in the words of the Mississippi Valley Committee, we shall "hand down our heritage not only unimpaired but enriched to those who come after us."

DISCUSSION

F. A. BARBOUR (*Boston, Mass.*): The Association is indebted to Mr. Cooke and Mr. Saville for two most interesting papers based on the work recently done by the Water Planning Committee of the National Resources Board. No engineer who has studied the report of this Committee can fail to be impressed with the magnitude of the task so quickly accomplished in this factual appraisal and preliminary evaluation of the problem involved in the future efficient use and control of the water resources of the country. Only by the most intensive work of the Committee, of which Mr. Cooke was Chairman and Mr. Saville, Executive Engineer, and of the regional and other consultants, could the mass of information contained in this report have been gotten together in the time available. I cordially endorse the statements made that the report is worthy of study by the members of this Association.

The paper of Mr. Saville is an exposition of the national importance of a better coördination of the multiple possible uses of our water resources—including domestic and industrial supply, sewage disposal, flood protection, power, navigation and the limitation or prevention of soil erosion—and of the necessity of the highest degree of planning for the proper evaluation of these multiple uses to the greatest public benefit and, as a base for such planning, the need of more adequate hydrologic data.

In these data he includes a more systematic and widely distributed collection of records of precipitation, stream flow, evaporation, snow surveys and ground water conditions. He argues for a definite and continued program for the comprehensive investigation of our water resources to be made under Federal auspices and he refers to the guiding principles set forth in the report of the Water Planning Committee as a possible basis for the further extension of the work done by that Committee. He emphasizes the necessity of organized effort in support of such a program to insure continued adequate funds and he recommends the active interest of this Association.

I think we will all approve Mr. Saville's argument and conclusions and his recommendation that this Association take an active interest in the further extension of the investigation of the problem of the coördinated use and control of water resources so well begun by the work of the Water Planning Committee. That such coördination is necessary for the best utilization of these resources and that addi-

tional systematic collection of basic data is required is beyond question.

I believe that we will agree that the further investigation of this coördinated use of water resources can best be made under Federal auspices. The trend towards Federal control of water as a national asset is evident. Certainly this Association must take a constructive position. The only question is as to how it can best register its position with those who will have to do with the further development of any program—whether in support or in criticism of what may be proposed.

The principal theme of Mr. Cooke's forceful, vivid presentation of his subject is the importance of soil erosion to our national existence. He permits himself to hazard the prediction that unless corrected, there remains to the nation, less than one hundred years of virile existence, and he estimates that to win out against this depletion of the soil, less than twenty years are available for the readjustment of present concepts of property rights in land and water and the development of the technique and procedure necessary for success. He discounts criticism by disclaiming the scientific accuracy of these estimates and by making evident that his immediate objective is the emphasizing of the importance and magnitude of the problem and the limited time available for its solution. He suggests and illustrates by diagram, an immediate and continued annual expenditure of 500 million dollars for twenty years as a reasonable program for the general improvement of our water resources and, most important, for soil erosion control.

It may be taken that, beyond its value in visualization of the problem and as an argument for appropriations adequate for further exhaustive investigation of the physical, legal and economic questions which will be involved in a centralized Federal control of all running waters "from desert trickle that may make an acre or two productive to the rushing waters of the Mississippi"—this suggested expenditure is not of much present significance.

What is needed is further investigation and this Association, recognizing the need of a better coördinated use of all waters and the probability of ultimate Federal authority over this great natural resource, should do everything in its power to facilitate such further investigation under some national planning agency, but until this investigation shall have been completed any suggestion of major expenditure for actual construction—other than what may be in-

cluded as part of the present program for unemployment relief—is, in my opinion, premature.

The present method of experimental approach to the solution of some national problems may have been justified by the existing emergency, but the extension of Federal authority from that now based on navigation to that which may require bureaucratic scrutiny and complicated procedure in all ordinary local waterworks and sewage projects with coincident implication of political abuse, is too important a change to be based on other than the most exhaustive study of all the conditions involved.

The importance of a better coördinated use of all water resources is too great to jeopardize the permanence of any program by initiating action not based on sound legal foundations, acceptance by the States, a definite principle for the allocation of betterments and a definite procedure which will adjust the activities of State and Federal authorities.

The most important recommendation of the Water Planning Committee is that for "an exhaustive study by an appropriate agency of the Federal and State legislation needed to permit effective coöperation between Federal, State, local and regional agencies in the conservation of water resources."

The most important condition in a permanent policy of conservation is the fixing of principles for the calculation of betterments and the equitable distribution of contribution to costs, and the danger lies in the political abuse possible in determining national interest in and resulting Federal contribution to any project.

What will be the effect of Federal control of all waters on the initiative and morale of State and local authorities? Will it by typical bureaucratic ineptitude retard rather than facilitate progress in the utilization of our water resources? Will it result in further governmental competition with private practice? How will it affect the economic status of the engineer concerning which the recommendation of the National Resources Board that a panel of consultant engineers be paid at a per diem of $25, with a minimum annual retainer, is not reassuring. What is the comparative relation of better coördination of the water resources of the country to other conditions controlling economic and social welfare? Soil erosion control is doubtless a pressing problem in some parts of the country, but in other sections where it is now being included as an argument for immediate large expenditures for river improvements, it is of minor

significance compared with the effect of higher taxes—however such taxes be imposed.

All of these are questions of immediate concern to our members pointing to the necessity for some action by this Association which will provide opportunity for effective registration of the opinions and needs of water works men in any further development of the scheme of Federal control of all waters.

ABEL WOLMAN (Baltimore, Md.): The papers presented this morning fall into three major classes. Those dealing with drought are expositions of a difficult water supply situation, temporary in character, but none the less serious in effect. They exemplify Benjamin Franklin's wise comment of years ago: "When the well's dry, they know the worth of water." The experience of the past 5 or 6 years justifies without doubt the emphasis which these papers are intended to stress. They present dramatic evidence of what may happen in a country of rich resources, in which advance thinking regarding the most useful development of these resources has been at times lacking.

The drought papers are followed naturally by the paper by Mr. Saville in which he outlines with considerable authority the underlying bases necessary for the determination of a national water policy. He shows with little contradiction in fact that this country has enormous deficiencies in water resources information which only the most comprehensive program can eliminate in the future. Without such determinations of fact any national water policy is likely to be doomed to failure. Hydrological data are unfortunately very meager in this country in comparison with any other country of much smaller proportions and of much more limited economic resources.

This was always the case in this country, even in the more fashionable days prior to 1929. Subsequent to that period, drastic budgetary cuts have decreased even those stations for the collection of data which were already too few in number.

For example, in England, over 7500 stream gaging stations have been in service for some years and a campaign is now under way for their rapid increase. In this country, less than 3000 may be considered of first class character.

We have only 200 good rainfall precipitation stations, while the number of stations for evaporation studies, namely, 100, is ludicrously small considering the variety of problems which confront a country as varied in its topographical and climatological features as the United States of America.

The paper by Mr. Cooke presents a general chart for future navigation. He points out with considerable dramatic interest that one of the richest countries in the world, through profligate use of its resources, may be confronted with less than 100 years of virile existence. The paper is characterized by a high degree of creative thinking and broad vision and certainly throws down the gauntlet to the American Water Works Association for carefully planned thinking for the future. We are here concerned with the important implications which these three groups of papers carry to professional workers in the water works field. Such implications involve social, political, legal and technical aspects.

The partial use or misuse of such an important resource as water supply, with its attendant effect on land use, has been presented many times in the past. It is only through recent catastrophes that the problem takes on new emphasis from the social standpoint. The drought, dust storms, the expanding and contracting deserts of the middle and far west, and the economic depression merely serve to give greater point to an old problem. From the political and legal angles one cannot escape the conclusion that new difficulties of state, interstate and federal coöperation are brought into the national picture to a degree which were only slightly sensed fifty years ago.

These problems naturally lead us to consider with great care the evolution of control of water resources toward centralization in Washington. Problems of states rights appear more frequently than ever. This Association must, of necessity, in the future determine which of these roads must be travelled to the greatest advantage of the public. Sharp demarcations between state and federal jurisdictions need not be the result. Experience in England and Germany may show that the way out for this country lies primarily in federal stimulation and coördination, with large proportions of local autonomy. It is by no means obvious that, because the problem is large and varied in character, complete centralization of plan and of execution is essential. It is obvious, however, that complete absence of national thinking and coördination may result in significant economic and social losses.

At the moment, however, the greatest significance of this group of papers lies in their importance to the members of the American Water Works Association. The papers by Saville and Cooke present a program of action for the Association. They chart a course in which statesmanlike thinking for the future will have ample room for play.

The Association owes a vote of thanks to the authors for pointing out the serious difficulties in which the country now finds itself and for suggesting the position which this Association can and should take in the development of a corrective program for the future. In the formulation of a national water policy, expenditure of money need not be the primary incentive. A rational plan for the future implies no extravagant expenditure of funds. It presupposes only that, when money is spent, it will be spent only after intelligent and careful review of the project itself. In such a program, the Association should be an active and guiding spirit.

THE MUNICIPAL WATER SUPPLY OF PARIS

By John B. Hawley

(Consulting Engineer, Fort Worth, Tex.)

The first domestic supply was carried to the houses by two-wheeled, horse-drawn carts bearing barrels or casks of varying capacity, averaging perhaps 60 or 70 U. S. gallons, loaded into the cask by buckets or crude pumps, from the River Seine. Some water also was pumped from shallow wells reaching into the gravel strata underlying the main part of the city (which gravels were quite pervious and utterly polluted by seepage from cesspools and "privies").

During the 4th century A.D. the Romans conducted spring waters by gravity from a point about 3½ miles southwest of the Emperor's Palace and baths to those structures by means of a 6¼-inch vitrified clay pipe, with cement joints in bells about 12 inches deep. The water was "soft" and in many respects like the underground waters of Fort Worth, Dallas and Waco, Texas.

They also built a masonry conduit or aqueduct of much greater dimensions tapping spring waters about 15 miles south of Paris, at Rungis and Wissous. The main section of this conduit was approximately 2½ by 6½ feet, the latter figure including the arch. This was known as the Arcueil Aqueduct.

About 1603, or 1604, Henry IV caused a pump station to be constructed on, and between piers of the Pont Neuf, near Notre Dame, to pump water from the Seine for use at his palaces and various public buildings. The pumps had reciprocating, duplex cylinders, driven by a paddle wheel of large diameter, the lower quarter of which dipped into the Seine, (à la old fashioned Mississippi "stern wheel").

Henry IV was assassinated in 1610 and his widow, Marie de Medicis, continued work in the way of a real water supply for the palace, the great parks and monumental fountains and for the City, as outlined by Henry IV to his favorite and most capable engineers.

Henry IV had already instructed Sully, his minister of finance (and chief engineer) to extend and improve the Arcueil (Roman) aqueduct, and Henry's widow assisted Sully in advancing the im-

provement of the conduit. (The new section being approximately 3½ by 7 feet.)

Her son, Louis XIII by Henry IV, did little to improve the water supply of Paris, nor did his son Louis XIV, although the latter improved general sanitation in some degree. (He wanted his Court to be the grandest and most luxurious Royal Court on Earth—but cared little how the money was got; we all remember "after me the deluge," which came, of course.)

Very little more was done on water supply for Paris until Napoleon came into power, and then he instructed a board of engineers to make surveys and find for him a route for a great canal running into a central point of the City. Incidentally, his minister gave an order to a rather youthful engineer, Girard, to pursue a canal route from Paris to the Ourcq—to a point near the debouchment of the Ourcq into the Marne.

The older engineers also studied a canal route to the Marne, but its "line" was quite different from that recommended by Girard. There was some talk of "discipline," etc. but one afternoon Napoleon summoned both the older engineers and Girard to the Tuileries for a "hearing" on the two plans. This was set for 3 P.M. and lasted through the splendid dinner at which Napoleon presided. At 2:00 A.M., having listened to all arguments, Napoleon came to a decision. He told the "Elders" that while Girard's plan was more costly, he deemed it the best, saying "Paris is the Capitol of the World, and must have the best; Girard will be Chief Engineer."

This was in 1802—but real use of the Ourcq canal as part of the "dual" water supply of Paris began in 1854; prior to that time it was part of the inland navigation system, and furnished water for street-washing and sewer-flushing. (There were two sets of pipes.)

Lead pipes, fabricated from flat sheets and of ovoid shape, soldered at the top and ends, were the rule (except for the water system at Versailles and a few other places), until the time of Belgrand, after whose advent cast iron came into general use for mains and laterals.

The elevation of the Paris end of the Ourcq canal (the Villette basin) was but 55 feet above the Rue de Rivoli, so pressures were very light.

Soon, however, Belgrand began to bring in additional underground and surface supplies and conditions greatly improved.

This brings us down to the "modern era" with Belgrand in chief command. Here I wish to pay my tribute to that great French

engineer. Frankly, I never heard of him except in the most casual way until I began a serious study of the Paris Water Works, in September, 1932, at the Library of the French Society of Civil Engineers.

It happens that during the course of the 48 years since I was graduated by the University of Minnesota, it has been my very rare good fortune to know more or less intimately a goodly number of the "fathers" of American Water Works and Hydrology, Alfred Noble, John R. Freeman, Daniel W. Mead, et al. I would have done my "devoirs" at the tomb of Belgrand had I been able to find the tomb.

(It seems that all Nations erect monuments and build tombs for conquering Field Marshals and Generals, but overlook the Builder, the Engineer.)

I have not finished my tribute to Eugene Belgrand, but will, thus: Eugene Belgrand belongs in the same class with Alfred Noble, John R. Freeman and Daniel W. Mead as to native mental endowment, engineering skill and actual accomplishments.

The modern water supply of Paris dates from 1854 (or shortly thereafter) when Belgrand was given "supreme command." (By the way, about this time Belgrand coined the word "hydrology, the science of water in all its states," and offered the suggestion that "all water supply engineers should be well schooled in geology.") Belgrand himself was a graduate of the École Polytechnique, and on his staff during the years of the Vanne development were the most noted and capable hydraulic engineers of those times.

Belgrand in 1854 reported in favor of the surface water from the Somme-Soude—together with "spring-waters" from the Epernay-Chalons region on the Marne about 100 miles east of Paris (the conduit to be 172 kilometres in length—110 miles).

The water was to be of quality safe for domestic use (potáble) and piped separately in the City from that of the Ourcq canal.

This "supply" Belgrand was not authorized to construct. It was perhaps "one of the things" where politics intervened (or whatever the proper word for that sort of folly may be).

Belgrand was so gentle in his reference to such delays to write "for several years the political situation has been such as to defer this quite necessary improvement."

(*To be continued*)

SOME ENGINEERING FEATURES OF THE ENLARGEMENT OF THE O'SHAUGHNESSY DAM

By Leslie W. Stocker

(*Chief Civil Engineer, Hetch Hetchy Water Supply, San Francisco, Calif.*)

In the year 1923 the City of San Francisco completed the high concrete O'Shaughnessy Dam, originally known as Hetch Hetchy Dam, which made a reservoir of Hetch Hetchy Valley, in the mountains of Tuolumne County, California. While it is in every respect a complete dam and has been in service ever since, it was contemplated from the start that at some later time its height should be increased to provide for greater reservoir capacity. That time has arrived; construction work is about to be commenced on an addition to enlarge the dam to increase the capacity by 75 percent. Such an addition to a structure of the type and magnitude of this dam is unprecedented, and involves special construction features to insure that immediately on completion the addition shall take up its proper share of the load and the entire mass of the enlarged dam shall act under stress in practically the same manner as if it had originally been built to the final dimensions as a whole. The design of the dam and the methods adopted to bring about the desired distribution of stress are described in this paper, without going into highly technical details.

HETCH HETCHY RESERVOIR

The Hetch Hetchy is the principal impounding reservoir of San Francisco's water supply and hydroelectric power system. The O'Shaughnessy Dam as it now stands gives a storage capacity of 67 billion gallons, with 220 feet depth of water at the dam. For ordinary municipal and domestic purposes the City's reservoir development here and elsewhere, aggregating 140 billion gallons, is ample for many years to come. However, ten years' experience in operation of the 80,000-kilowatt power development dependent primarily on Hetch Hetchy storage, under more favorable conditions for disposal of power than were at first anticipated, has demonstrated the

economic value of greater storage capacity for the purpose of power generation. For this reason the second and final section of the O'Shaughnessy Dam is now to be built. It will increase the capacity at Hetch Hetchy to 117 billion gallons, with 306 feet maximum depth.

THE EXISTING DAM

The dam is a concrete gravity-type structure, arched in plan, with the following principal dimensions: height 226 feet above stream bed and 344 feet above the lowest point in the foundation; crest length 605 feet; maximum thickness at the base 308 feet; arch radius 700 feet, measured to a reference arc close to the upstream face. It contains 398,000 cubic yards of concrete. The design for a dam of the height now proposed was made prior to construction of the present dam, and the base portion of the existing dam, below stream bed level (elevation 3500 feet), was built to the full size required for the ultimate dam, to make work below stream bed level unnecessary in the future construction. Above elevation 3500 the dam is of only normal dimensions for its present height, except for a block containing six of the outlet conduits, which is of full thickness for the ultimate dam. Thus there is a shelf 80 feet wide on the downstream side at elevation 3500 to serve as foundation for the addition.

The downstream side of the dam above the level of the shelf is finished in steps 5 feet high, intended to assist in bonding the addition to the existing structure. Copper water-stops were inserted in the crest surface, near the upstream face, half imbedded in the concrete, the other half, now folded back into a temporary wooden box, to be unfolded and imbedded in the concrete of the addition, to insure watertightness along the joint. The spillway consists of 18 siphons, each 10 feet long and 4 feet high at the top. A similar water-stop surrounds each siphon, to seal the joint between the old concrete and the concrete that will plug the siphon. The shelf, the steps, and the water-stops are all the provisions made in the original construction for later work, except as to a few minor details. Six radial vertical contraction joints divide the dam into 7 blocks averaging about 90 feet in length, measuring along the upstream face. The joints have never been grouted, as the design did not contemplate the development of arch action.

THE ADDITION

The enlargement of the dam will be accomplished by building an addition against the downstream side of the part of the present dam

above elevation 3500 to increase the thickness, and continuing the addition to a crest elevation 85.5 feet above the present crest. The final height will be 312 feet above stream bed, and 430 feet above the lowest point in the foundation, the maximum thickness at the base remaining 308 feet. The addition requires 268,000 cubic yards of concrete, making a total for the enlarged dam of 666,000 cubic yards.

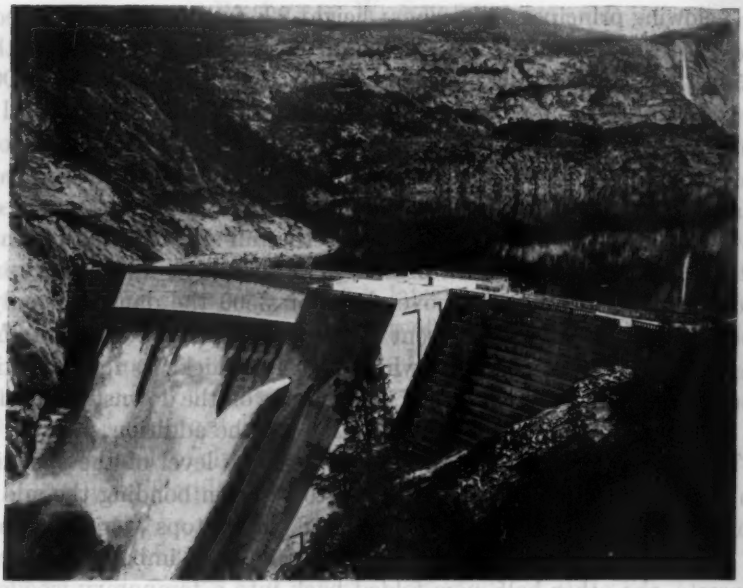


FIG. 1. DOWNSTREAM FACE OF O'SHAUGHNESSY DAM

The large central block contains 6 discharge conduits, and its downstream face will become a portion of the downstream face of the enlarged dam. The steps on the remainder of the downstream face are 5 feet in height. The addition will be carried up to a height 86 feet above the existing crest. The new side channel spillway will be at the right outside the picture. The existing siphon spillway shown on the left will be plugged.

The general dimensions of the addition were fixed by the original design, and no substantial change was found desirable on thorough review. The distance between existing contraction joints is much greater than is used in present-day practice, and in the new work, not only will the present joints be extended, but additional joints will be formed midway between them. Thorough drainage of the joint between the old downstream face and the new concrete will

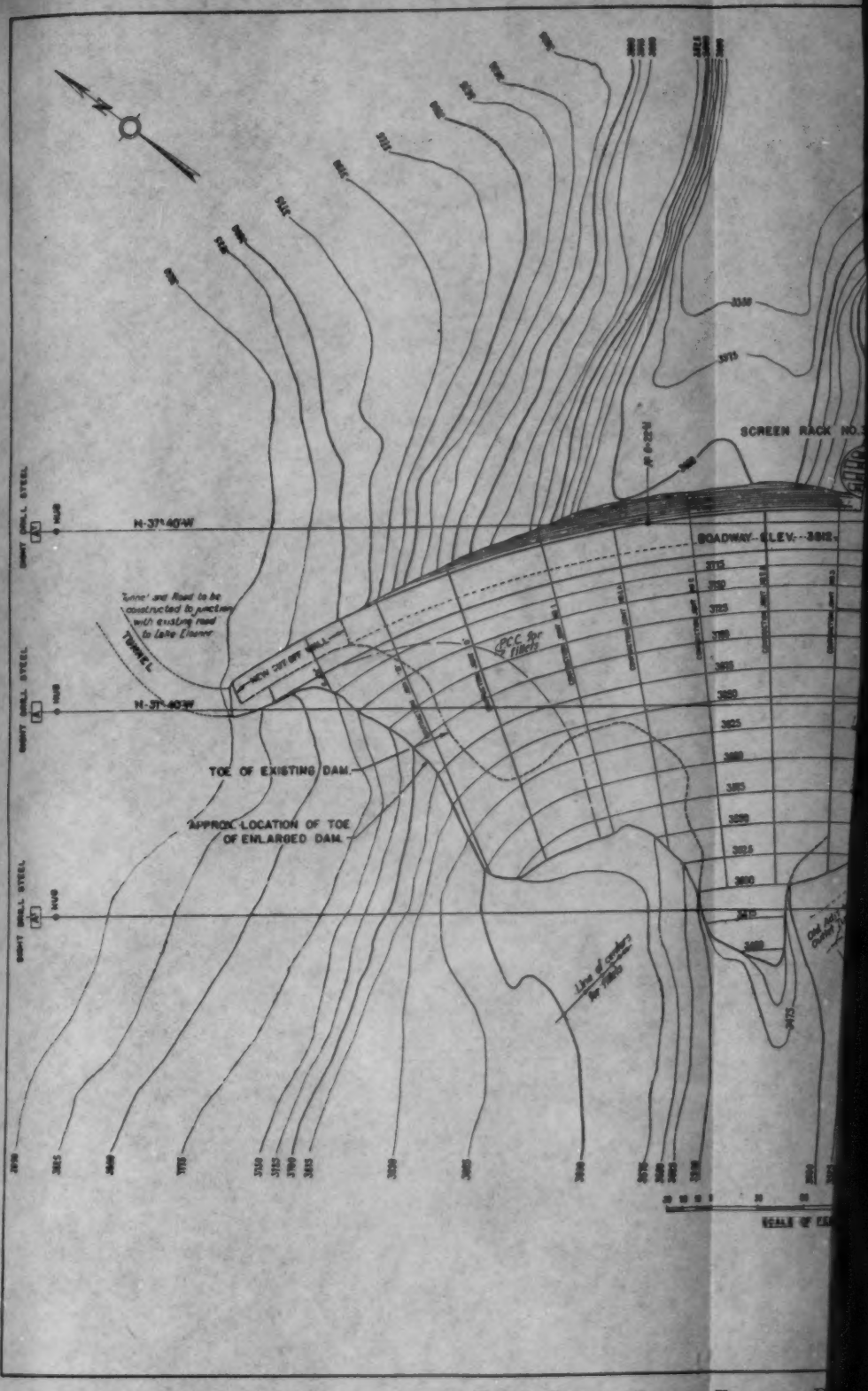
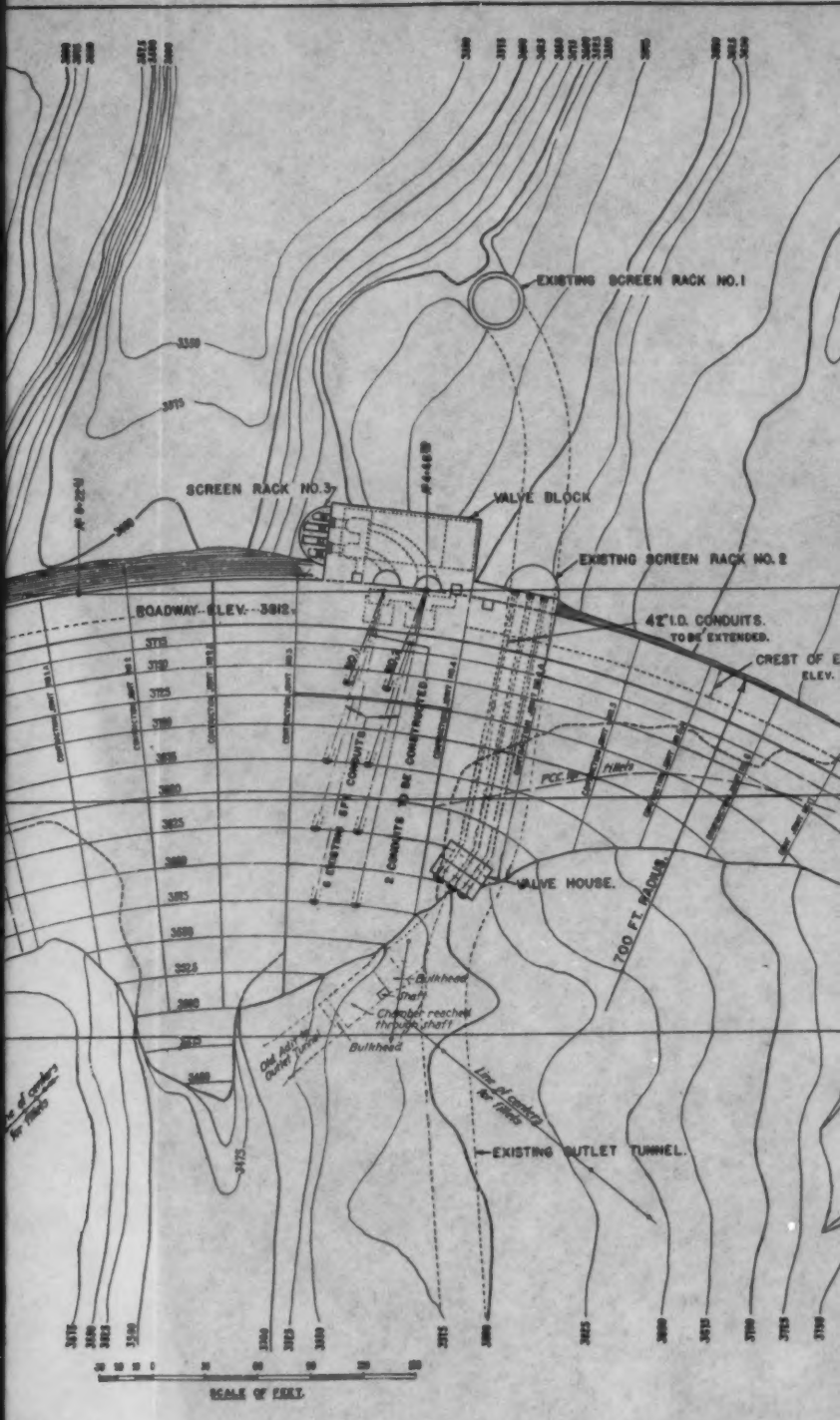
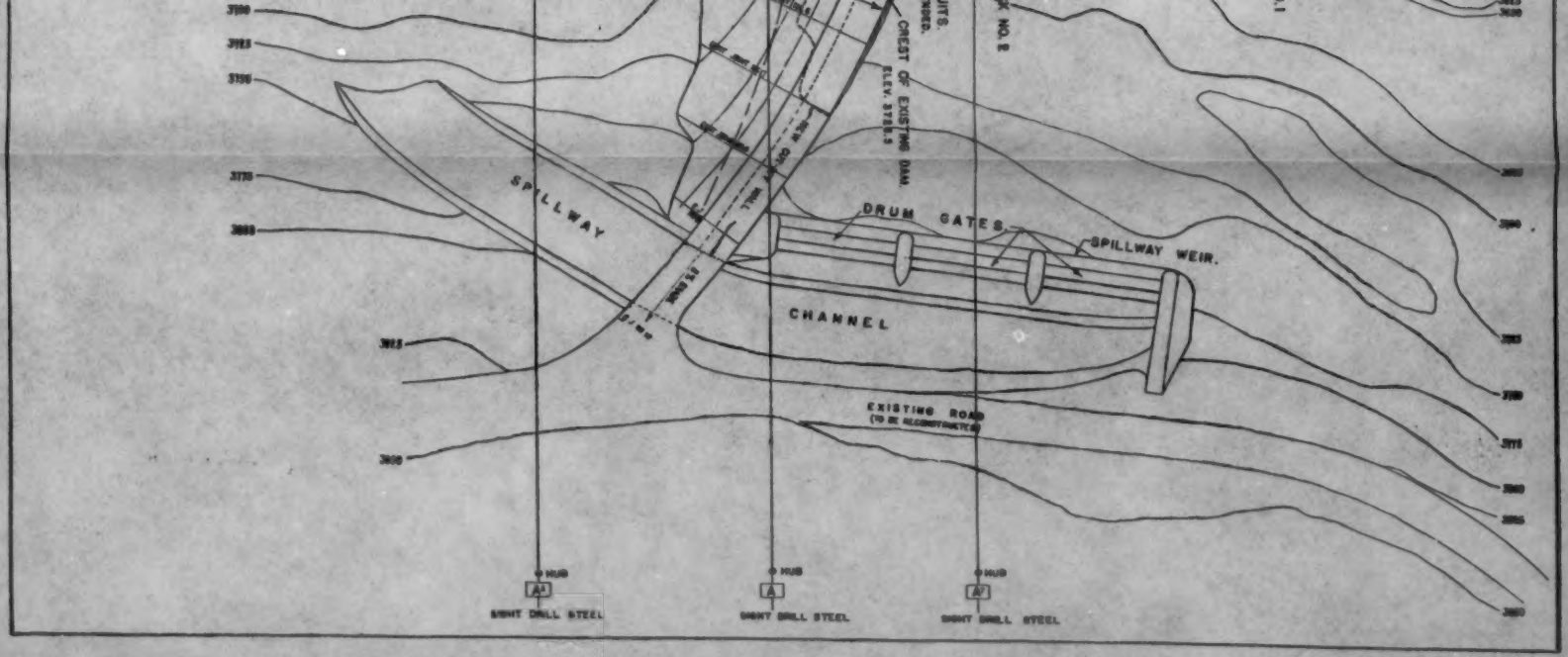

SCREEN RACK NO.3
H-37°40'W
ROADWAY - ELEV. - 3912.
Tunnel and Road to be constructed to junction with existing road to Lake Eleanor
TUNNEL
NEW CUT OFF WALL
PCC for Filters
H-37°40'W
TOE OF EXISTING DAM.
APPROX. LOCATION OF TOE OF ENLARGED DAM.
SHAFT DRILL STEEL
Line of center for Filters

FIG. 2. GENERAL PLAN OF ENLARGED D



ERAL PLAN OF ENLARGED DAM. (Note toe of existing dam, shown by dotted line



(Dotted line)

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be provided for by installing a drain along each of the 5-feet steps, opening into a gutter in an inclined inspection gallery that will follow the line of each of the old contraction joints along the present downstream face. The usual provisions for inspection and drainage are made in the part of the dam above the present crest elevation.

The most interesting problem in adding the new section is that of making the present dam and the addition act together as a homogeneous structure. The concrete is now 12 to 15 years old, and in that time has undergone practically all the shrinkage that normally occurs in the process of setting and cooling, as well as other physical changes. Furthermore, the addition will be constructed while the old concrete is under stress due to the head of water in the reservoir. If the addition were built by simply pouring new concrete against the old, then on completion the water rising to the new flow line of the reservoir would cause the old part of the dam to become greatly overloaded, because of the superior characteristics of the old concrete resulting from its age, and because of the old concrete being already stressed by external load during construction while little or none of this load could be transmitted to the new concrete.

It is planned to bring the new concrete to approximately the condition of the old within the construction period by two expedients:

1. By making concrete that will initially be of a somewhat higher grade than the existing concrete when the latter was poured;
2. By artificial cooling of the concrete.

The first object can probably be secured without excess cost, as the methods of producing and placing concrete in these days of more scientific concrete construction are greatly improved as compared with those of twelve to fifteen years ago, and correspondingly better results are now obtained with materials of the same quality without increase in the quantity of cement in a given mass.

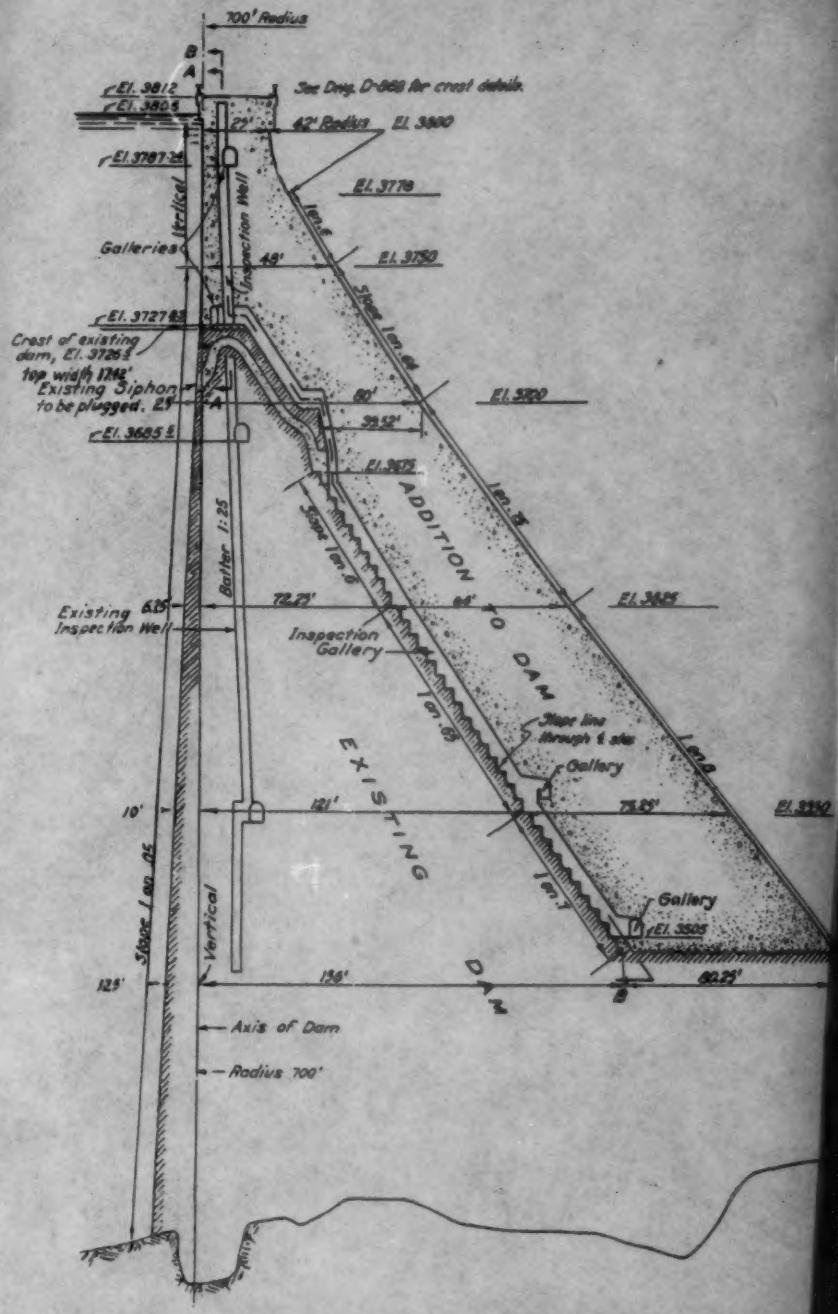
The second object requires the use of a refrigerating plant and a system of piping for the circulation of cooling water through the mass of the dam. By this means reduction in temperature that would normally require years in such a mass of concrete will be caused to occur within the space of a few months.

The arrangement for cooling will be substantially the same as has been used in the construction of the Boulder Dam. Cooling pipes will be arranged in horizontal layers or coils, with one-inch pipes spaced 5.5 feet apart in each horizontal layer, and 5 feet vertical distance between layers. Connections will be so arranged that water

from the reservoir may be circulated through any coil without artificial cooling while the concrete temperature is considerably above that of the reservoir water, and until the difference in temperature between the water and the concrete adjacent to the coil is no longer sufficient to maintain the desired rate of cooling, after which direct use of the reservoir water in the coil will be discontinued and the water taken from the refrigerating plant to complete the cooling process. Two independent systems of supply and return header pipes, graduating from 8 to 2 inches diameter, are required, one for direct circulation of reservoir water, the other for refrigerated water, and each coil will be connected through valves to both header systems. This makes it possible to circulate water from the reservoir through recently poured blocks of the dam at the same time that refrigerated water is being used to complete the cooling of older concrete. Arrangements will be made for observing temperatures in the concrete mass, and the rate of cooling will be controlled by adjusting the rate of flow of the water so as to cool as rapidly as possible while avoiding excessive differences of temperature between the concrete immediately adjacent to the cooling water pipe and that more remote from the pipe, which might set up permanent internal stresses within the mass; and also avoiding subjecting recently poured concrete to such a low temperature as would unduly retard its setting.

The bulk of the concrete placed on the downstream side of the existing dam will not be poured directly against the present downstream face, but slots having an average thickness of about 5 feet will be left open along the joint between the new concrete and the old, only narrow ribs being poured against the old concrete to support the weight of the new. The filling of the slots with concrete will lag sufficiently behind the pouring of the main bulk to permit the greater part of the shrinkage of the latter to occur before the slot is filled. The subsequent shrinkage of the concrete placed in the slot will be a very small matter, and practically negligible. However, provision will be made for grouting whatever crack may develop between the two masses of concrete due to this shrinkage.

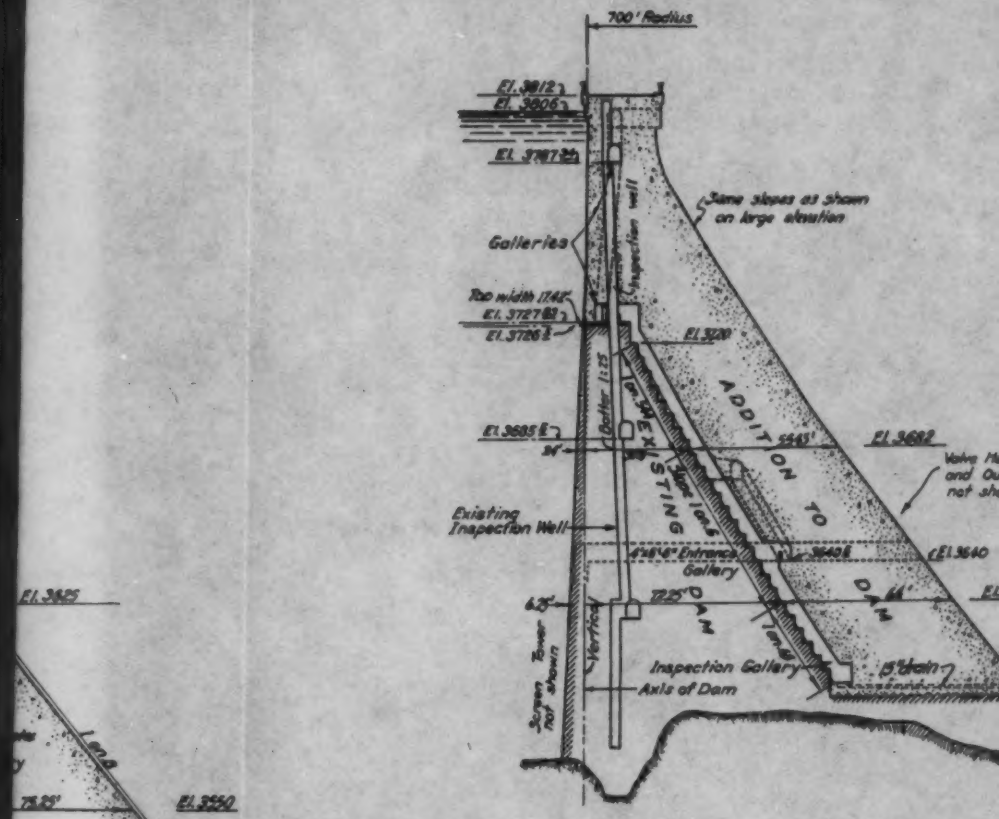
Provision is also made for grouting the contraction joints in the new section of the dam through a system of pipes, and in the old section through holes to be drilled in the existing concrete. The extent to which such grouting will be resorted to is not yet determined, but the specifications are flexible enough to provide for any



SECTIONAL ELEVATION OF ENLARGED DAM

SECTION AT INSPECTION GALLERY BETWEEN EXISTING DAM AND ADDITION TO DAM AT CONTRACTION JOINT NO. 2. TYPICAL FOR PORTION OF DAM CONTAINING SIPHON SPILLWAYS.

FIG. 3.

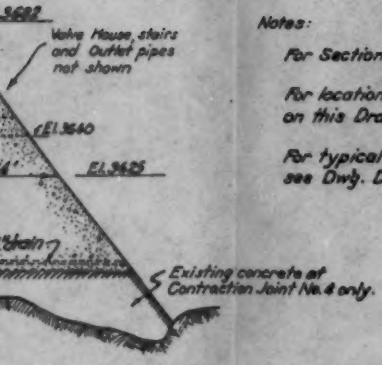


SECTIONAL ELEVATION OF ENLARGED

SECTION AT INSPECTION GALLERY BETWEEN EXISTING DAM AND ADDITION TO DAM AT CONTRACTION JOINT NO. 4 TYPICAL FOR PORTIONS OF DAM NORTH OF SIPHON SPILLWAYS AND SOUTH OF VALVE BLOCK.

NLARGED DAM
GALLERY
ND ADDITION
OINT NO. 2.
DAM
LWAYS.

FIG. 3. TYPICAL SECTIONS SHOWING DAM AS IT NOW EXISTS AND AS ENLARGED



Notes:

For Sections A-A and B-B, see Dwg. D-867.

For locations of Contraction Joints referred to on this Drawing, see Dwg. D-867.

For typical section of dam through valve block, see Dwg. D-873.

NLARGED DAM
GALLERY
D ADDITION
JOINT NO. 4.
F DAM
VAYS
OCK.

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amount that may be considered necessary on later study, and on observation of the concrete both old and new during construction. The old section may be grouted to develop arch action, while the new is left ungrouted to act by gravity only, or vice versa; or both may be grouted to secure both gravity and arch action in the entire dam. By cooling the new concrete to a temperature below that of the old, grouting all the joints in the new, and then allowing the temperature to rise, possibly even causing it to rise by circulating warm water, it may be possible to induce stress in the new concrete to develop a considerable amount of arch action which would greatly assist in obtaining the desired object of making the two sections of the dam act homogeneously together.

The contact surfaces between old and new concrete will be roughened in the usual manner to assist the bonding, and in addition, where stresses of considerable magnitude cross joints in directions that are not nearly normal to the joint surfaces, notches will be cut in the old concrete to provide for transmission of stress in compression and eliminate high shearing stress along the joint. For further mechanical bond between old and new work, steel anchor bars will be set in the existing downstream face and their projecting ends will be imbedded in the new concrete. For this purpose holes $2\frac{1}{4}$ inches in diameter will be drilled 5 feet into the concrete, at intervals of 5 feet vertically and 2 feet 6 inches horizontally. The bars will be $1\frac{1}{4}$-inch square reinforcing steel, about 15 feet long, grouted into the holes and projecting about 10 feet into the new work.

The siphon spillway of the present dam will be replaced by a channel spillway at the south end of the dam, with a weir crest 195 feet long in three sections, each section having a radial gate 10 feet in height, with provisions for automatic operation. Ten of the siphons will be plugged with concrete during the earlier part of the construction period, the other eight, supplemented by the outlet conduits, being sufficient to handle the river flow during construction. The eight will be extended, first by means of flumes and then through the new concrete, and left open until the new spillway is ready for use. The concrete filling the siphons will also be subjected to cooling and grouting.

Although the contract for constructing the addition to the dam has been awarded, the City's engineering bureau does not by any means assume that all of the problems involved in the work have been solved. Experimental work, observation of the behavior of

the concrete initially placed, and tests of this concrete are relied upon to give additional information that will either confirm the information already at hand, or serve as a guide in making changes for either improvement or economy. For this reason many of the details mentioned above are to be regarded as tentative or approximate.

ORGANIZATION

The enlargement of the dam is a project of the Hetch Hetchy Water Supply, a department of the Public Utilities Commission of the City and County of San Francisco. The plans and specifications for the project were drawn up under the direction of the following personnel of the Hetch Hetchy Water Supply: L. T. McAfee, Chief Engineer and Manager; M. M. O'Shaughnessy (died October 12, 1934), Consulting Engineer; Leslie W. Stocker, Chief Civil Engineer; R. L. Allin, Hydraulic Engineer. Mr. O'Shaughnessy was Chief Engineer of the Department at the time of the construction of the existing dam. Construction is under the general supervision of Messrs. McAfee and Stocker, with John H. Ryan, Construction Engineer, in direct charge in the field.

The plans and specifications were reviewed by the designing staff of the United States Bureau of Reclamation, acting in a consulting capacity, and by the Division of Water Resources of the Department of Public Works of the State of California, which under state law has jurisdiction over dams in the interest of public safety.

The contract for the enlargement of the dam was awarded April 8, 1935, to Transbay Construction Company, at the estimated total price of $3,219,265. This company is a combination of five contracting concerns, three of which are members of Six Companies, Inc., the firm building the Boulder Dam.

DESIGN AND CONSTRUCTION OF THE MORRIS DAM FOR THE CITY OF PASADENA

By Samuel B. Morris

(Chief Engineer and General Manager, Water Department, Pasadena, Calif.)

The Morris Dam is the principal construction unit of the recently completed San Gabriel Water Supply Project of the City of Pasadena. A number of interesting or unusual problems were met in the design and construction of this project.

1. Determination of the proportion of San Gabriel River stream flow percolating into ground-water basins under varying natural conditions.
2. Correlation of surface storage in San Gabriel Canyon with ground-water storage at Pasadena for maximum yield.
3. Design of dam to resist earthquake shocks.
4. Underdrained concrete lining of right abutment spur to prevent percolation under pressure into fractured rock.
5. First use of cement with specified low-heat of hydration.
6. Placing concrete with less than 1-inch slump by use of both internal and external platform type vibrators.
7. Model tests used in design of spillway.
8. Special observations and studies of strains, deflections and distribution of stresses in the mass concrete, and of temperatures and uplift.

The construction of this 328 foot high concrete gravity section dam involving 610,600 cubic yards of excavation and placing of 514,000 cubic yards of concrete was begun April 26, 1932 and just 25 months after ground was broken, the dam was dedicated May 26, 1934 by former President Herbert Hoover in these final words:

"On behalf of those far-seeing leaders of this community, the engineers whose skill has brought this plan to practical realization, and the community which has given to them their loyal support, I dedicate the Morris Dam to the service of a hundred generations of Americans who will receive the blessings."

The dam creates a storage reservoir about four miles in length with capacity of 39,300 acre-feet, or 12,800 million gallons. The reservoir is located in San Gabriel Canyon from which a 36-inch all-welded

steel pipe line conveys the water 18½ miles by gravity to the Sunset and Wilson distribution reservoirs within the City of Pasadena.

The completion of this project, which has been in use since May 26, 1934, has more than doubled the available water supply of the City, and should enable the City of Pasadena with a present population of about 80,000, and population served of 92,500, to grow to a population of from 180,000 to 200,000 inhabitants.

PRIOR WATER RIGHTS PROTECTED

The San Gabriel Project was conceived early in 1923 at which time prior water filings in San Gabriel Canyon were purchased and the City made application in its own behalf to the State Division of Water Resources. On July 1, 1923, the State began an intensive hydrographic survey of the San Gabriel River; the survey lasted for five years and resulted in permits being issued to the City of Pasadena to store an average of not more than 30,000 acre feet per annum (27 m.g.d.) of the flood waters of the San Gabriel River.

The San Gabriel River drains a mountainous area of 210 square miles above the Morris Dam. This area varies in elevation from 930 feet at the dam site to over 10,000 feet at the crest of the highest mountains. Precipitation of 20 to 35 inches occurs from November to April, there being little or none from May to October. The mean annual stream flow is 115,000 acre-feet, while annual discharge has varied from 9,600 to 410,000 acre-feet. Rates of stream flow vary from a minimum of 3 cubic feet per second to a maximum of 40,000 in the flood of January 1916.

About three miles below the Morris Dam, the river emerges from the mountains and discharges over the porous sands and gravels of the San Gabriel Valley, the stream dividing into many smaller streams spread over a large area of the detrital cone. About 10 miles below the mouth of the canyon, the main river divides into two channels, the left channel passing to the east of El Monte, thence through San Gabriel Narrows and across the Coastal Plain entering the sea at Seal Beach. The right branch of the river passes to the west of El Monte through the westerly portion of San Gabriel Narrows, and enters the Los Angeles River, and thence flows into the sea through the flood control channel west of Long Beach. From the mouth of the San Gabriel Canyon to about the Valley Boulevard near El Monte, the river contributes large quantities of its flood water to the ground-water basin. From about Valley Boulevard to the Narrows, ground

water is close to the surface and both the San Gabriel River and the Rio Hondo are rising streams, which again sink into the ground below the Narrows in the Coastal Plain.

By establishment of a large number of stream gaging stations and securing the record of fluctuation of water levels in a large number of wells, the State was able to determine for any rate of flood flow, the quantity of water which would percolate into the ground, and the quantity which would waste to the sea. When ground water is high

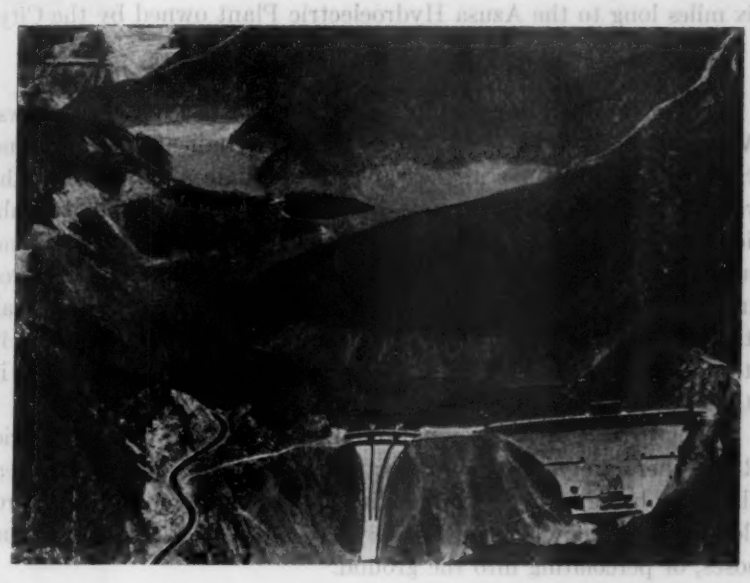


FIG. 1. AIRPLANE VIEW OF MORRIS DAM AND RESERVOIR TAKEN JULY 11, 1934

Note, left to right, State Highway, access road leading from State Highway to Dam, Spillway and Spillway Bridge, parking space and dam. The reservoir was cleared to maximum high water. In the upper left hand corner may be seen the Quarry for the Los Angeles County Flood Control District's rock fill San Gabriel Dam No. 1.

in San Gabriel Valley, the point of rising water moves upstream and there is less length and area of percolating channel.

Charts embodied in the permits issued to the City of Pasadena by the State on July 9, 1928 indicate the quantity of water which will percolate for any rate of mean daily discharge from San Gabriel Canyon for any elevation of ground water in Central San Gabriel Valley. The difference between the flood flow at the mouth of the canyon and the water which will percolate as determined by the

chart, is water which would normally waste to the sea. This water which wastes to the sea is unappropriated flood water which the State, by its permits, has granted to the City of Pasadena.

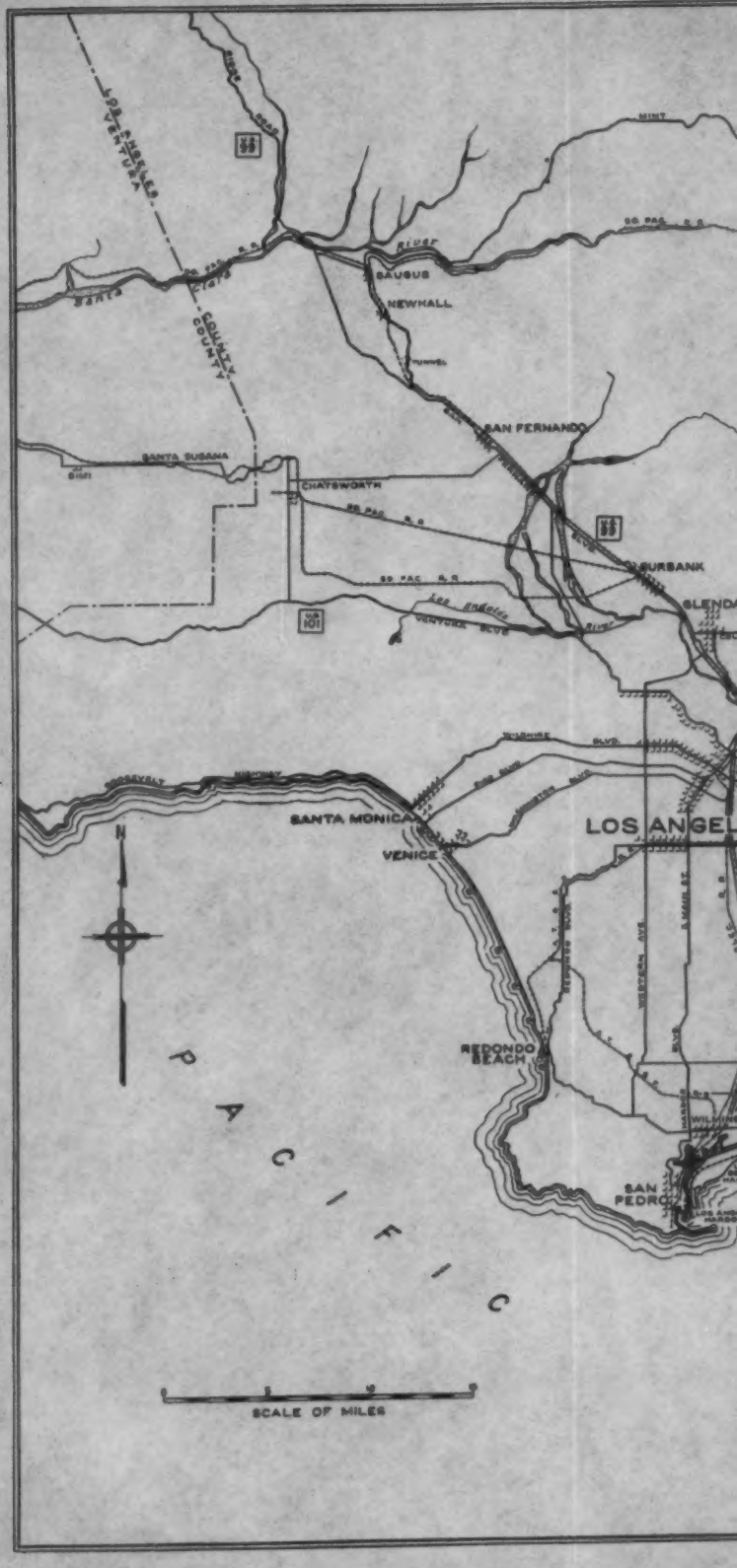
In addition to the water which would normally percolate the City must release the natural underflow and low-water flow at the dam site amounting to one second-foot, and must release the water heretofore diverted from surface stream flow, constituting the total flow of the river up to 90 second-feet, which is diverted through a conduit six miles long to the Azusa Hydroelectric Plant owned by the City.

PLAN OF OPERATING RESERVOIR

The plan of operating the Morris Dam and Reservoir is as follows: Whenever flood flows occur which the chart indicates would cause waste of water to the sea, the valves in the dam are closed and the water is retained in storage until such time as the flood has subsided to such stage as water would no longer reach the sea. A computation is made of the normal percolation which would have occurred under natural conditions and this quantity is released in a small stream such that it will wholly percolate. The water remaining in storage is then salvaged flood water which the City may retain in storage for diversion to Pasadena.

Owing to wide fluctuation in rainfall and run-off of the San Gabriel River, there are years when no water would normally reach the sea, all water being either diverted directly through the Azusa Hydroelectric Plant, now owned by the City, and used for irrigation purposes, or percolating into the ground.

In order to secure a constant source of water supply for the City it has therefore been necessary to combine the San Gabriel surface supplies with the local ground water supplies. The City of Pasadena overlies two ground-water basins fed by the surface water of the Arroyo Seco, Eatons Canyon and other small mountain drainage areas. Since 1917 ground-water levels have fallen 60 to 150 feet in the local ground-water basins due to subnormal rainfall and drafts in excess of the safe yield. The City plans to use the surface water from its San Gabriel Project, and from the Arroyo Seco and Eatons Canyon supplies owned by the City as the first primary sources of supply. When these supplies are not available in dry periods, the City will become dependent upon extraction of ground water from beneath the City, which ground water will have accumulated during wet or average years while the City has been using surface water.


VENTURA COUNTY
LOS ANGELES COUNTY
SAUGUS
NEWHALL
SAN FERNANDO
SANTA SUSANA
CHATSWORTH
BURBANK
GLENDA
SANTA MONICA
VENICE
LOS ANGEL
REDONDO BEACH
SAN PEDRO
P A C I F I C
N
SCALE OF MILES

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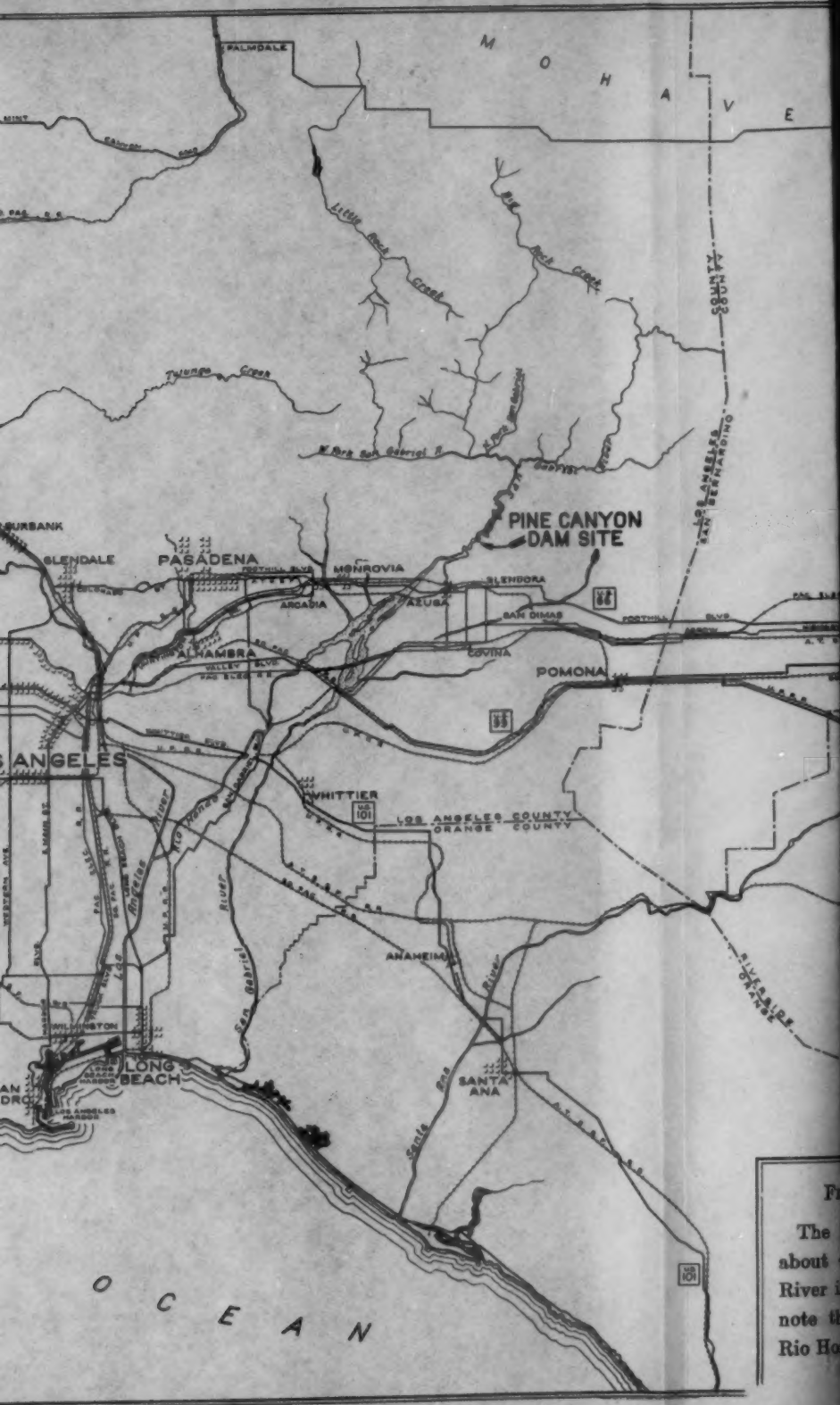

PALMDALE
M O H A V E
Little Rock Creek
Rock Creek
Pacoima Creek
W. Fork San Gabriel R.
PINE CANYON DAM SITE
BURBANK
GLENDALE
PASADENA
MONROVIA
ARCADIA
AZUSA
SIERRA MADRE
ALHAMBRA
COVINA
POMONA
LOS ANGELES
WHITTIER
LOS ANGELES COUNTY
ORANGE COUNTY
ANAHEIM
LONG BEACH
SANTA ANA
San Gabriel River
Santa Ana
O C E A N

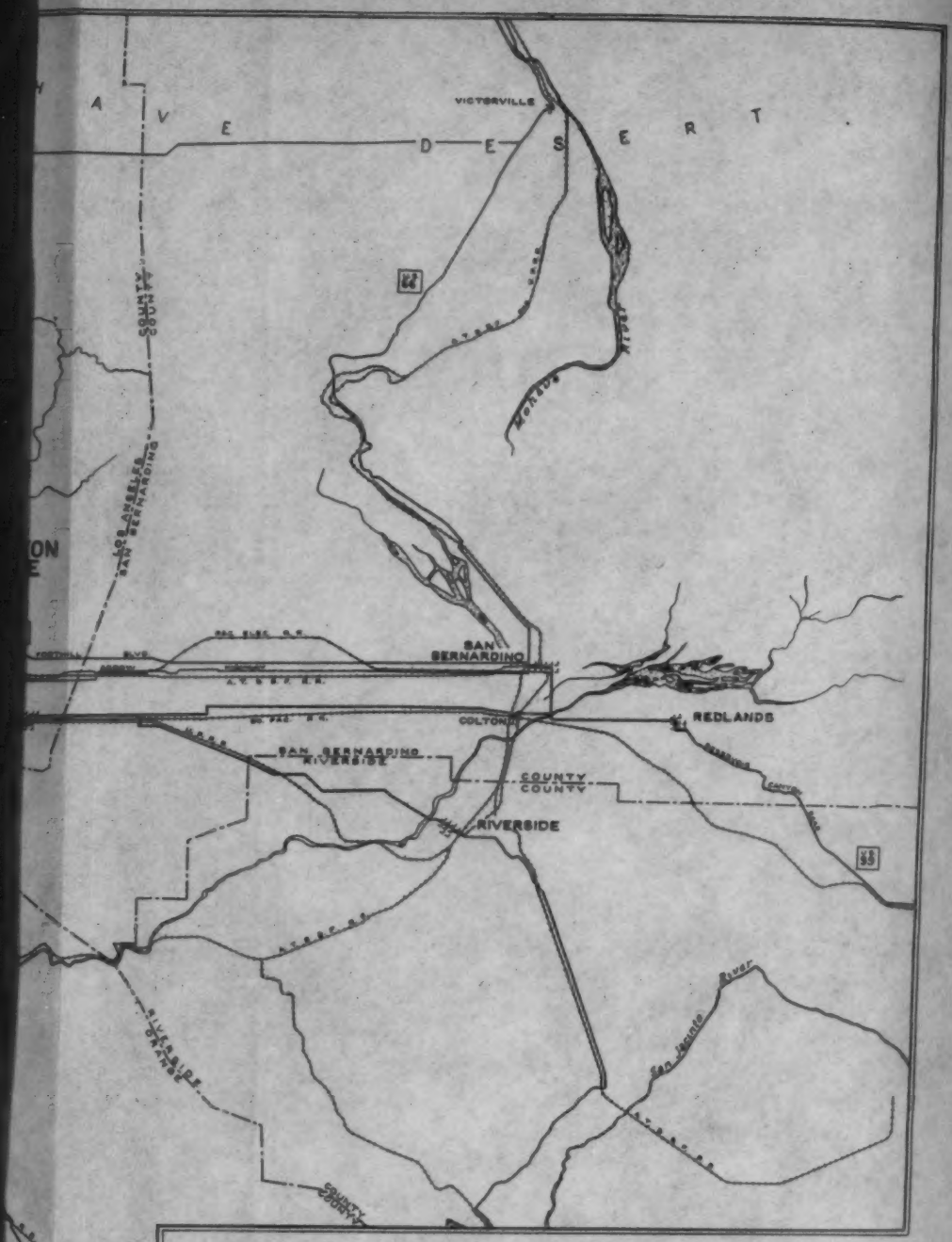


FIG. 2. PINE CANYON (MORRIS) DAM—GENERAL LOCATION MAP

The location of the Morris Dam (formerly Pine Canyon Dam) is shown about 4 miles above Azusa. The large absorption area of the San Gabriel River is shown between the mouth of the canyon and Valley Boulevard. Also note that the river divides into two channels, the San Gabriel River and Rio Hondo.

A monthly hydrograph based upon daily computations from 1904 to 1930 shows the average yield of the San Gabriel Project to be 15,500 acre feet per annum which may be increased to 17,500 acre feet per annum by local spreading of San Gabriel River water. The combined yield of the San Gabriel Project and local projects is 29,000 acre feet per annum and requires a net surface storage capacity of 37,260 acre feet supplemented by local ground-water storage of 125,000 acre feet.

GEOLOGY OF THE DAM SITE

The San Gabriel Mountain Range is a great block of metamorphic and igneous rocks, lying between two major fault zones, the San Andreas rift on the north and the Sierra Madre fault at the face of the mountain range on the south. As a whole, the range is an uplifted block or horst. The main mass is divided into subsidiary blocks by various minor faults, the principal one of which, the San Gabriel Fault, has determined the erosion of the east-west valley occupied by the west fork and the east branch, the principal tributaries of the San Gabriel River.

The dam site is located in the narrowest point of the main San Gabriel Canyon between the Sierra Madre and the San Gabriel faults, being about two miles from the former and five miles from the latter.

The rock at the site is mainly a granodiorite gneiss, which in places becomes dark or hornblendic and thus grades into a rather basic diorite gneiss. Associated with this gneiss are irregular masses of aplite and diabase dykes. Numerous insignificant faults, shear planes and joints exist in the dam site, but there is no evidence of recent movement. In fact, lack of displacement in the stratification of old streambed gravels establishes the fact that there has been no material motion in a period of the order of ten thousand years. One such minor fault intersects the dam foundations near the base of the right abutment in a direction nearly normal to the axis of the dam. This fault has been made the subject of special treatment, which is described later in the article.

EXPLORATION OF THE SITE

Probably more thorough exploring and testing of the Morris Dam site was done prior to completion of plans than has been done for any other dam. The general character of rocks in the San Gabriel

Mountains and the large overburden of decomposed rock on the abutments and deep gravel deposits in streambed demanded great thoroughness. Several dam and reservoir sites were surveyed and two dam sites were explored in order to determine the best site.

The major part of the exploratory work was done by driving small tunnels and sinking shafts. Altogether 23 tunnels, with a total length of 2,760 feet were driven into the abutments, including one tunnel that was driven across the canyon below streambed. As an aid in exploration, the first half mile of the main outlet tunnel was driven into the right abutment. There were seven shafts sunk, an aggregate of 520 feet. Diamond coredrilling consisted of eleven holes for a total footage of 875. Altogether there were 4,155 feet of exploration tunnels, shafts and diamond coredrilling, in addition to the driving of the half mile outlet tunnel.

Later excavation of foundations and abutments revealed the sufficiency of the exploration work, and no material relocation or redesign of the dam was necessary on account of unforeseen conditions. Some of the exploration tunnels were permanently left open for drainage or inspection including those below streambed beneath the dam.

DESIGN OF MORRIS DAM

Consideration was given to all types of design, and several designs and estimates were prepared including the use of other dam sites, before the final adoption of a straight gravity concrete dam as the type best adapted to the topographic and foundation conditions, with proper considerations of safety and economy.

Weight of concrete was assumed to be 150 pounds per cubic foot. Actually test specimens cut from the dam have weighed 155 pounds, and 14 by 28 inch compression cylinders made in the laboratory with full-sized aggregate have weighed 157 to 158 pounds.

Uplift was considered as varying from 100 percent at the upstream face to 50 percent at the line of drains, just upstream from the galleries, and then diminishing uniformly to zero or backwater pressure at the downstream toe; all considered as acting on 100 percent of the area. The foundations near the upstream face of the dam are grouted through a double line of grout holes in the deep cut-off trench, staggered 5 feet apart and 30 feet in depth. In addition, 150 foot grout holes have been driven in the cut-off trench at about 20 foot intervals.

Drainage holes are provided in the dam on 10 feet centers, and

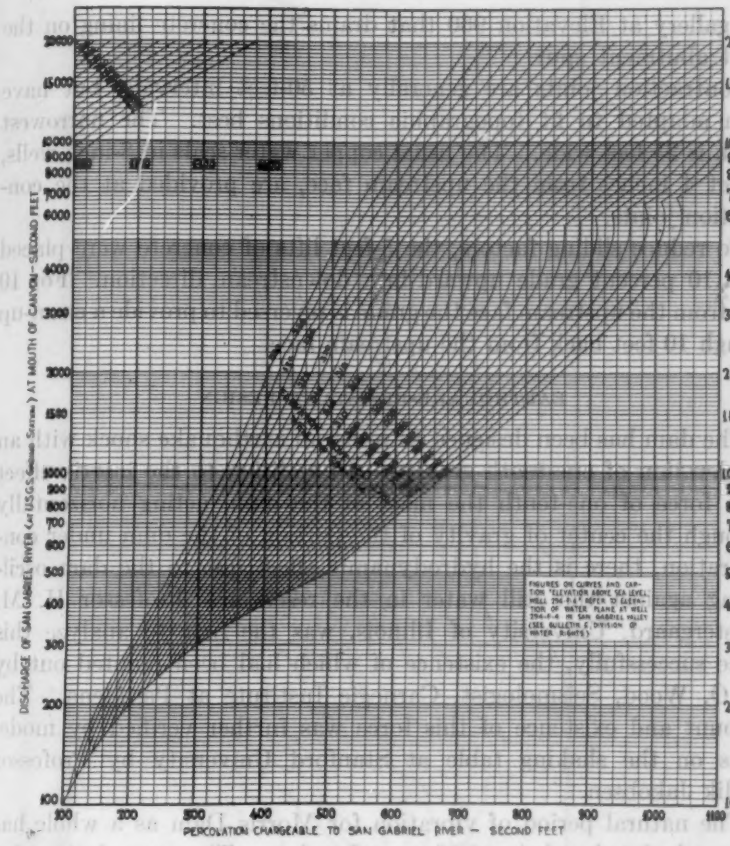

DISCHARGE OF SAN GABRIEL RIVER (at U.S.G.S. Gaging Station) AT MOUTH OF CANYON—SECOND FEET
PERCOLATION CHARGEABLE TO SAN GABRIEL RIVER — SECOND FEET
FIGURES ON CURVES AND CAPTION "ELEVATION ABOVE SEA LEVEL, WELL 294-F-4" REFER TO ELEVATION OF WATER PLANE AT WELL 294-F-4 IN SAN GABRIEL VALLEY (SEE BULLETIN E, DIVISION OF WATER RIGHTS)

FIG. 3. PERCOLATION IN SAN GABRIEL WASH CHARGEABLE TO WATER FROM THE SAN GABRIEL CANYON

As an example of a typical computation from this chart: Assume a flood with a mean daily discharge of 2,000 cubic feet per second at the mouth of San Gabriel Canyon (entering the Morris Reservoir)—Under natural conditions, and with a ground water level in Well No. 294-F-4, we find from the chart that the percolation would have been 400 cubic feet per second: The difference between 2,000 and 400 or 1,600 cubic feet per second would have wasted into the sea. If the ground water had been 276 feet a much greater length and area of percolating channel would exist and we find from the chart, would have provided a percolation of 850 cubic feet per second: The difference between 2,000 and 850 or 1,150 cubic feet per second would have percolated.

extend 30 feet into the foundation rock. In the right abutment, drainage wells extend from the cut-off trench to an intersection with

the gallery at Elevation 960 that drains the concrete lining on the right abutment spur.

Contraction joints are generally at 50-feet intervals, but have been adapted to fit topographic conditions best. The narrowest block is 25 feet wide. The usual copper water seals in 8-inch wells, 2 feet 4 inches from the upstream face, are provided at the contraction joints.

To reduce sliding factors, the 5-feet lifts of concrete were placed on a 10 percent grade upward in a downstream direction. For 10 feet from the upstream face the grade is reversed to provide a clean-up trough 10 feet back from the upstream face.

EARTHQUAKE-RESISTANT DESIGN

The dam has been designed to resist an earthquake shock with an acceleration of one-tenth gravity. In addition to the inertia effect of a force of one-tenth the mass of the dam, acting horizontally through the center of gravity of the portion of the dam under consideration, there is the hydrodynamic effect due to the dam oscillating against the still water in the reservoir. Professor H. M. Westergaard, University of Illinois, was the first to analyze this force successfully, the existence of which had been pointed out by H. O. Wood, Seismologist, Carnegie Institute at Pasadena. The amount and existence of this force was further verified by model tests on the shaking table at Stanford University by Professor Lydik Jakobsen.

The natural period of vibration for Morris Dam as a whole has been calculated as being 0.16 second or less. The more destructive earthquakes are usually the ones with fairly large amplitudes and longer periods, and the smaller temblors are usually associated with the shorter periods such as this. Also there is plenty of evidence that earthquakes do not have a constant period of vibration, even for a short period of time so that the probability of resonance to a serious degree seems remote.

As to vertical acceleration, it has been shown that this has no overturning effect upon a dam, because the weight of the dam and water are both effectively changed at the same time in the same proportion. The vertical acceleration does, however, cause a slight effect upon the unit stresses.

The effect of the conservative assumptions of uplift and the inclusion of earthquake forces is shown by the adopted cross-section of

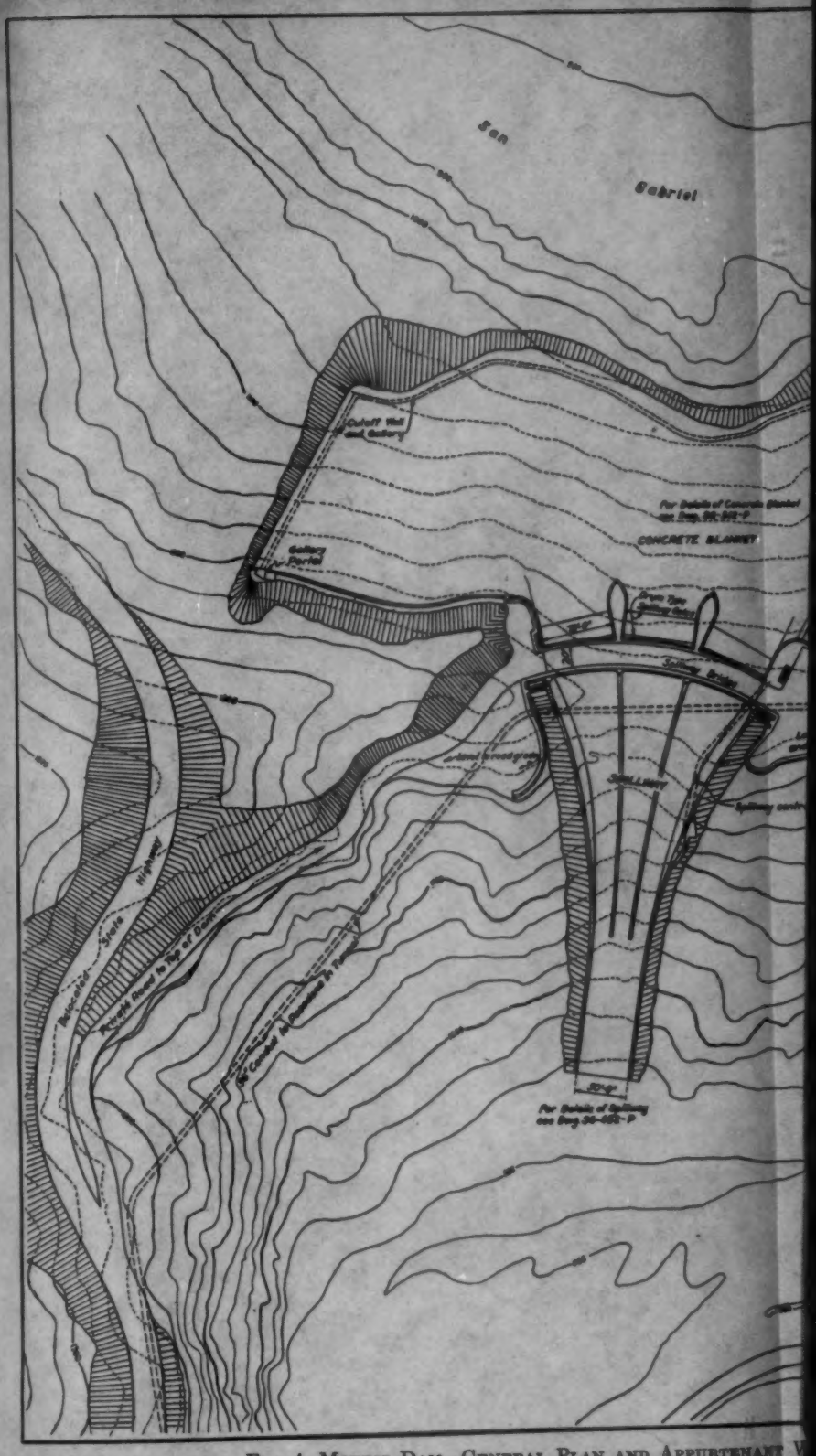
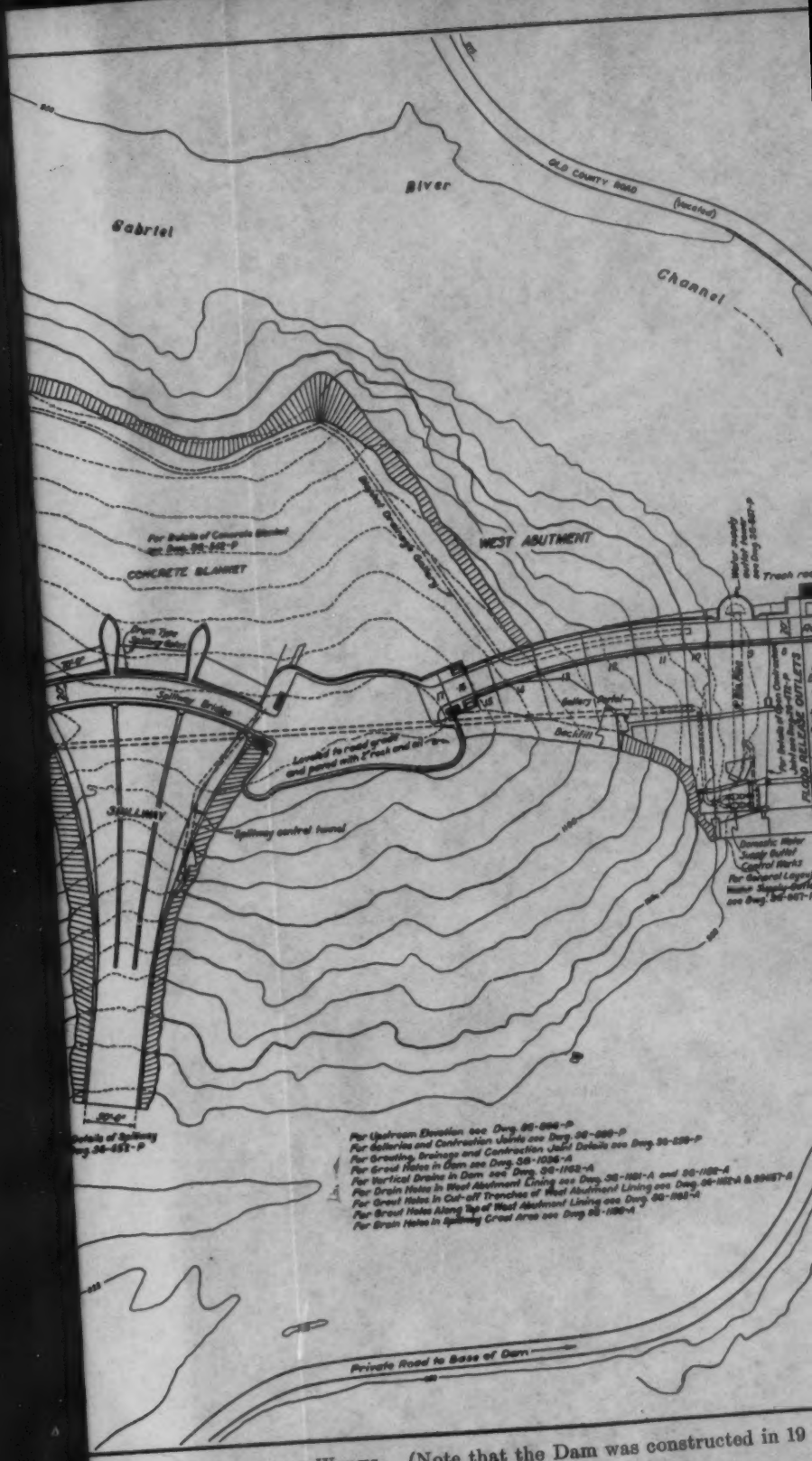
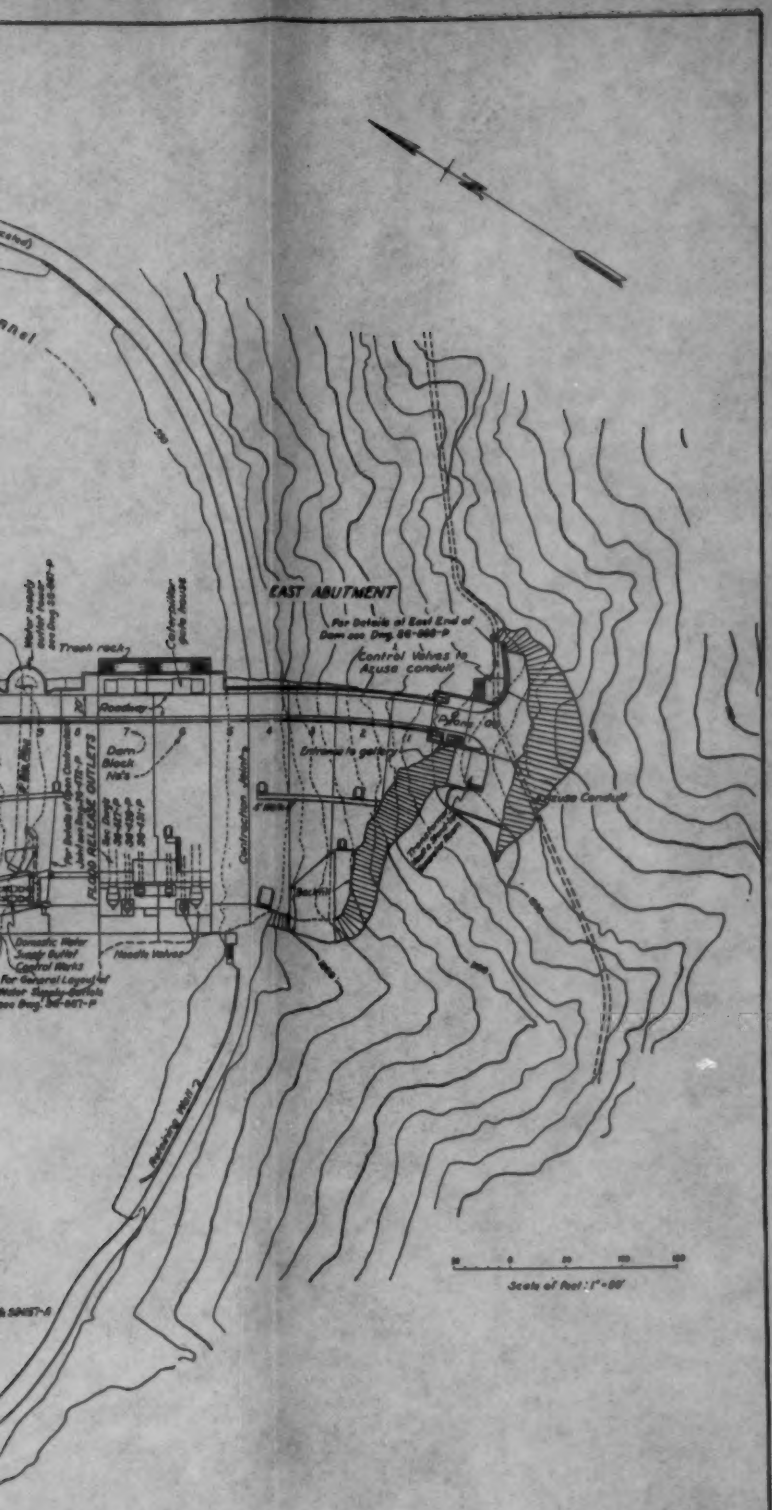


FIG. 4. MORRIS DAM—GENERAL PLAN AND APPURTENANT W


Gabriel
River
OLD COUNTY ROAD (located)
Channel
WEST ABUTMENT
CONCRETE BLANKET
SPILLWAY
Spillway control tunnel
Backfill
Gallery Control
Trench
FLOOD RELEASE OUTLETS
Domestic Water Supply Outlet Control Works
Private Road to Base of Dam
For Upstream Elevation see Dwg. 26-696-P
For Galleries and Contraction Joints see Dwg. 26-698-P
For Grouting, Drainage and Contraction Joint Details see Dwg. 26-699-P
For Grout Holes in Dam see Dwg. 26-1036-A
For Vertical Drains in Dam see Dwg. 26-1102-A
For Drain Holes in West Abutment Lining see Dwg. 26-1101-A and 26-1106-A
For Grout Holes in Cut-off Trenches of West Abutment Lining see Dwg. 26-1107-A & 26457-A
For Grout Holes along Top of West Abutment Lining see Dwg. 26-1108-A
For Drain Holes in Spillway Crest Area see Dwg. 26-1109-A

LAN AND APPURTENANT WORKS. (Note that the Dam was constructed in 19



in 19 blocks, numbered from right to left 00 to 17)

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the dam, which has an upstream batter of 0.05 to 1 and a downstream slope of 0.81 to 1, or a base width of 0.86h for the straight section of the dam. The dam contains about 15 per cent more material as a result of this thickening to resist earthquake forces.

To fit the topography of the site better, the abutment sections are curved to a radius of 716.3 feet. Consideration was given to the effect of converging radii upon the stability of the curved sections, which were accordingly made thicker than the straight sections. The upstream batter is the same 0.05 to 1, while the downstream slope was increased to 0.875 to 1 above Elevation 970 and 0.95 to 1 below that elevation. Arch action was not considered, because of the fault located along the base of the right abutment.

TREATMENT OVER FAULT

The fault near the base of the right abutment dips into the hillside at an angle of about 60 degrees northwest and has a strike nearly perpendicular to the axis of the dam. The striations on the fault, whether in the oldest decomposed rock near the surface or in the fresh rock at depth, are all in the same direction, dipping about 60 degrees downstream, indicating that the direction of fault movement has always been about the same. As has been previously stated, lack of displacement of old streambed gravels indicates that there has been no movement in the fault for a period of probably 10,000 years.

Over the trace of the fault an open joint has been provided with vertical sliding planes from bottom to top of the dam between blocks 8 and 9. These vertical sliding planes are four in number, at an angle of nearly 45 degrees to the horizontal, and lie in the direction of resultant motion as shown by the strike, dip and striae on the fault. Planes of contact are separated with a bituminous filler which can yield if motion is slightly at variance from the predetermined direction. Between the vertical sliding planes are 3 foot open spaces extending the full height of the dam. The maximum motion accommodated is 6.55 feet in either direction along the striae or direction of motion.

During such maximum earth motion the open space between the adjacent blocks will be either closed to zero or opened to 6 feet from the present width of 3 feet. Accordingly, the blocks adjacent to this joint have been designed to carry an additional water load of 6 feet.

WATER SUPPLY OUTLETS

The outlet tower was completely redesigned after the City of Pasadena entered into an agreement with the Metropolitan Water District of Southern California to sell the Morris Dam and Reservoir for the District's use in storing Colorado River water when this supply is available for distribution to Pasadena. The semi-circular outlet tower as redesigned has eighteen 2 by 8 feet slide gates connected with 3½-inch stems and operated by hydraulic cylinders at the top of the dam. These gates are placed in pairs at 19¼ feet differences in elevation with the sill of the lowest gate at Elevation 1000. Semicircular removable screens in about 10 feet sections, four sections to the gate, are lowered in front of the particular outlets in service.

A 9 by 9 feet slide gate at the outlet of the tower affords emergency control over a 9 feet diameter outlet pipe; until used by the Metropolitan Water District, this 9 feet pipe terminates at the downstream face of the dam. From near the end of this outlet, a 42-inch pipe takes off for Pasadena's use.

After passing through a 42 inch by 21 inch venturi meter tube the water passes through two 30 inch by 24 inch needle valves in parallel, either of which will pass the full capacity of 40 second feet. These needle valves are used for throttling purposes to regulate the supply released to Pasadena. Each needle valve is flanked on either side by a 30 inch and a 24 inch electrically operated square-seated gate valve. The 24 inch valves have follower rings.

WATER TREATED WITH AMMONIA-CHLORINE

A separate room is provided on the downstream face of the dam for treatment of the water with chlorine and ammonia. Separate scales are provided to receive two ton cylinders of chlorine and three 150 pound cylinders of ammonia. The scales are equipped with circular charts for recordation of weight of chlorine and ammonia used.

Chlorinators, capacity 100 pounds per day, and ammoniators, capacity 35 pounds per day, for use of anhydrous ammonia are provided in duplicate. Ejectors are used to force the gas into the 42-inch pipe line. The pipe shortly reduces to 36 inches diameter and extends 18.5 miles to the Sunset and Wilson Reservoirs at Pasadena. Here aeration is provided to increase the dissolved oxygen and improve the potability of the water. At the present time no filtration is pro-

vided. During the first season the reservoir was treated with copper sulphate on three occasions to control algae growths.

FLOOD RELEASE OUTLETS

Six flood release outlets, with one common trashrack structure of 3,160 square feet net area on the upstream face of the dam have a maximum capacity, reservoir full, of nearly 7,000 second feet. While the existing river channels downstream from the dam do not afford percolation area sufficient to absorb a flow greater than 650 second feet, subsequent improvements may greatly increase this capacity.

The Los Angeles County Flood Control District has plans to create large spreading grounds to increase percolation. It may be necessary at times, also, to release large flows to break up the streambed gravels that tend to become sealed from conditions of low regulated stream flow.

At Elevation 975 there is one 54-inch and one 48-inch outlet for normal release of flood water, each equipped with venturi meters and two 96-inch outlets for occasional large release. At Elevation 960 there are two 48-inch outlets for the primary purpose of sluicing any silt from beneath the other four flood release outlets.

Each of the outlets is equipped with a free discharge, hydraulic-balanced, needle valve at the downstream face of the dam, to be used for normal operating conditions. In a gallery near the upstream face the 54-inch outlet and each of the 48-inch outlets is equipped with hydraulically operated slide gates for emergency use. The 96-inch valves are similarly equipped with electrically operated butterfly valves for emergency use.

As a final precaution, in case any of the emergency valves themselves should need attention, an 8 by 10 feet tractor gate has been provided on the upstream face of the dam. This gate is operated by a 100-ton traveling hoist located in a hoist house at the crest of the dam. Each of the several sized outlets has a mouth belled to an 8 by 10 foot gate frame to fit the tractor gate leaf.

Each of the six flood release outlets consist of electrically welded steel pipe downstream from the emergency gates in the operating gallery. The 96-inch pipes are $\frac{1}{2}$-inch in thickness and the 54- and 48-inch pipes are $\frac{3}{8}$-inch in thickness. Upstream from the emergency gates the pipes are A. W. W. A. cast iron flanged pipe.

The 54- and 48-inch pipes are connected to the 8 by 10 foot tractor gate seats by cast iron, bell-mouthed transitions. The bell mouths on the 96-inch outlets are formed in the mass concrete of the dam.

SPILLWAY

The spillway was designed to discharge 80,000 second feet, or twice the maximum recorded flow. Three automatic, floating-drum type spillway gates, hinged downstream, were installed. They are of all-welded steel construction. Each gate is 70 feet long and 18 feet high. The spillway is located about 200 feet west of the west abutment of the dam over the spur that comprises the west abutment, and the channel is located in a slight draw or ravine on the downstream side of that spur. The draw is so shaped that if the spillway channel were run full width all the way down the hill, there would be excessive excavation at the channel side walls, so it was decided to converge the spillway channel side walls from 210 feet at the crest to 50 feet at the discharge lip.

Several models were made on a scale of 1:48 to assist in determining the best design. The adopted coefficient of discharge is 3.45. It was evident that there was a distinct advantage in putting the gates on chords of an arc, giving the water through each gate a start in a direction that would necessitate the least possible amount of deflection. If the correct lines of flow are affected initially, they do not have to be changed, or, if done near the top where the velocities are low, they may be changed more easily than down the channel even a short distance, where the water is beginning to attain quite a high velocity. Tests showed the most economic results were obtained by an angle of 19°51′09″ between the chords of an arc upon which the drum gates were placed.

Vertical side walls were found to keep the water within the channel better than would sloping side walls. Further, vertical walls were better suited to cantilever-wall construction. In a converged channel, when one end spillway gate only is discharging, the water has a tendency to follow its initial direction and jump the opposite side wall near the bottom. To control this, center walls down to Elevation 1014 were put in to keep the water from each gate in its own particular part of the channel. These walls were very successful and were put in to the necessary height and length downstream to accomplish the desired result, as determined by the model experiments. According to the model study, at an 80,000 second feet discharge, the freeboard near the top is about 5 feet where the velocities and depths cannot vary much from the computed or observed, and it gradually increases until at 150 feet downstream the freeboard is 10 feet where the stream may be more inclined to flutter. The model

tests showed the length and shape of the bridge piers that extended upstream from the spillway bridge had a very marked effect in controlling wave action in the spillway channel throughout its length.

A model to a 1:240 scale, representing about ½ mile of channel, was also constructed to determine the proper elevation and dimen-

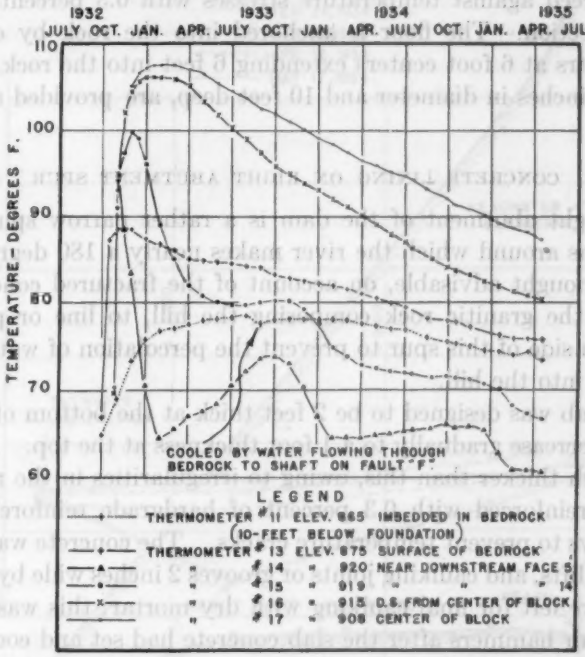
1932
1933
1934
1935
JULY OCT. JAN. APR. JULY OCT. JAN. APR. JULY OCT. JAN. APR. JULY
TEMPERATURE - DEGREES F.
110
100
90
80
70
60
COOLED BY WATER FLOWING THROUGH BEDROCK TO SHAFT ON FAULT "F"
LEGEND
THERMOMETER # 11 ELEV. 865 IMBEDDED IN BEDROCK (10-FEET BELOW FOUNDATION)
THERMOMETER # 13 ELEV. 875 SURFACE OF BEDROCK
" # 14 " 920 NEAR DOWNSTREAM FACE
" # 15 " 919 " " " 14
" # 16 " 915 D.S. FROM CENTER OF BLOCK
" # 17 " 909 CENTER OF BLOCK

FIG. 5. MORRIS DAM—CONCRETE TEMPERATURES IN BLOCK NO. 7

Concrete in the interior mass rose in temperature about 36°F. above the placing temperature to a maximum of 107.5°F. At the end of April 1935 the temperature in the center of the block has dropped to 87°, a fall of 20° in the 2½ years since the concrete was placed. Thermometers placed within 5 feet of the dam faces reached near mean annual temperature in about 6 months' time.

A thermometer placed in bedrock 10′ below the dam foundation showed an increase of temperature of 13°F. in the first year and has fallen 5° in the 1½ years since reaching its maximum, but is still 8°F. above the mean annual temperature of 65°F.

sion of the spillway discharge lip to cause minimum scour below streambed. The spillway lip adopted is a cantilever structure substantially at streambed level 800 feet downstream from the dam and discharging upward at a gradient of 40 percent.

The foundation of the spillway cantilever is carried down 40 feet into the rock to insure against any possible undercutting.

The floor of the spillway was poured monolithically and directly on rock with a specified average thickness of 2 feet, which overran considerably because of the irregular surface of the rock. The floor is reinforced against temperature stresses with 0.3 percent steel in each direction. The floor is anchored into the rock by one inch square bars at 6 foot centers extending 6 feet into the rock. Weep holes 1½ inches in diameter and 10 feet deep, are provided at 6 foot centers.

CONCRETE LINING ON RIGHT ABUTMENT SPUR

The right abutment of the dam is a rather narrow spur of the mountains around which the river makes nearly a 180 degree bend. It was thought advisable, on account of the fractured condition of some of the granitic rock composing the hill, to line or pave the upstream side of this spur to prevent the percolation of water under pressure into the hill.

The slab was designed to be 2 feet thick at the bottom of the hill and to decrease gradually to a 1 foot thickness at the top. Actually it is much thicker than this, owing to irregularities in the rock. It is fully reinforced with 0.3 percent of hardgrade reinforcing steel both ways to prevent temperature cracks. The concrete was poured in 5 foot lifts, and caulking joints or grooves 2 inches wide by 4 inches deep were left for final caulking with dry mortar; this was tamped in with air hammers after the slab concrete had set and cooled.

The slab is underdrained with continuous 4-inch round tile drains set in ditches in the rock and surrounded with gravel. The drains run down the slope in the steepest direction on about 15 foot centers. They terminate at the lower end in a drainage tunnel or gallery formed in the concrete of the cut-off trench along the lower edge of the lining. This gallery drains the water to the downstream face of the dam. The 4-inch drains, in general, are not inter-connected and were laid on as nearly straight lines as possible so that they may be rodded out, or so that any leakage that may develop in the slab can be located, and if necessary can be sealed by grouting.

PRESSURE WATER SYSTEM

Treated water is pumped from the outlet control house on the downstream face of the dam at elevation 985.5 to a 15,000 gallon

concrete tank at elevation 1400 feet on the mountain side west of the spillway and State highway. Water from this tank is available

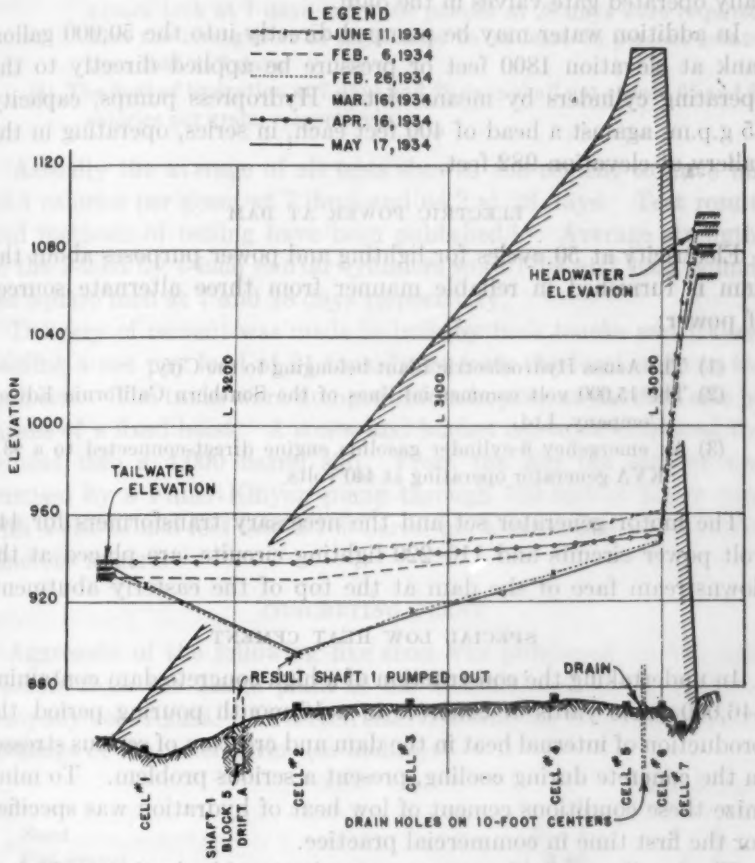

FIG. 6. MORRIS DAM—UPLIFT MEASUREMENTS

The effectiveness of grouting at the cut-off trench and the drains immediately downstream from the cut-off trench is shown by the drop in uplift pressures at all times at the drainage gallery to amounts only 5 to 10 feet in excess of the tail water elevations.

The two low records of uplift pressure on February 22, 1934 and May 17, 1934 were due to pumping out Drift A which crosses beneath the downstream toe of the dam.

about the dam site and in the galleries of the dam for washing purposes.

An automatic pump beside the tank raises the water to a second tank with a capacity of 50,000 gallons at elevation 1800 feet. Water from this tank is conveyed by a 1½-inch brass pipe line to all hydraucally operated gate valves in the dam.

In addition water may be pumped directly into the 50,000 gallon tank at elevation 1800 feet or pressure be applied directly to the operating cylinders by means of two Hydropress pumps, capacity 75 g.p.m. against a head of 400 feet each, in series, operating in the gallery at elevation 982 feet.

ELECTRIC POWER AT DAM

Electricity at 50 cycles for lighting and power purposes about the dam is furnished in reliable manner from three alternate sources of power:

(1) The Azusa Hydroelectric Plant belonging to the City.
(2) The 15,000 volt commercial lines of the Southern California Edison Company, Ltd.
(3) An emergency 6-cylinder gasoline engine direct-connected to a 93.6 KVA generator operating at 440 volts.

The motor generator set and the necessary transformers for 440 volt power circuits and 110–220 lighting circuits, are placed at the downstream face of the dam at the top of the easterly abutment.

SPECIAL LOW HEAT CEMENT

In undertaking the construction of a high concrete dam containing 446,000 cubic yards of concrete in a 16-month pouring period the production of internal heat in the dam and creation of serious stresses in the concrete during cooling, present a serious problem. To minimize these conditions cement of low heat of hydration was specified for the first time in commercial practice.

The locally available cements gave heats of hydration at 28 days of 90 to 110 calories per gram. Tests conducted by the Riverside Cement Company and the University of California for the Boulder Dam investigations showed that cement of lesser heat of hydration and other desirable characteristics could be ground commercially.

The City's specifications provided for a true Portland cement to meet the requirements of the Standard Specifications for Portland Cement of the A. S. T. M. with the following exceptions and additions:

(1) Fineness shall require not less than 92 nor more than 98 percent passing a 200 mesh sieve.

(2) Tri-calcium aluminate shall be not less than 1 nor more than 6 percent by weight.

(3) In place of tensile tests compressive tests of 2-inch x 4-inch cylinders of 1:3 mortar were provided. Strengths of at least 800 pounds per square inch at 7 days and 2,000 pounds at 28 days were required. Also the strength at 28 days must be at least 35 percent greater than that at 7 days.

(4) The heat of hydration at 7 days and 28 days shall not exceed 65 and 80 calories per gram, respectively.

Actually the average of all tests showed the cement to have but 55.3 calories per gram at 7 days and 64.2 at 28 days. Test results and methods of testing have been published.[1,2] Average strengths of the 2-inch by 4-inch mortar cylinders were 1769 and 4003 pounds per square inch at 7 and 28 days respectively.

Delivery of cement was made in bulk by tank trucks and trailers hauling a net pay load of 21 tons direct from the local mills to the dam site. The tanks were dumped into a hopper at the dam site by means of a fixed hoist. A screw and bucket conveyor delivered the cement into a 4,000 barrel silo. From the silo the cement was pumped by a Fuller-Kinyon pump through 730 feet of 5-inch pipe with a rise of 300 feet into a 700 barrel bin located directly over the concrete mixers.

CONCRETING PLANT

Aggregate of the following five sizes was purchased by the contractors from the Largo plant of the Consolidated Rock Products company near Azusa. All screen sizes but sand are based upon round openings of diameter given (in inches):

	Screen size	*Analysis size Square openings*
Sand	0 – $\frac{1}{4}$	0 – $\frac{1}{4}$
Pea gravel	$\frac{1}{4}$–$1\frac{1}{2}$	$\frac{1}{4}$– $\frac{7}{8}$
Medium gravel	$1\frac{1}{2}$–$1\frac{3}{4}$	$\frac{7}{8}$–$1\frac{1}{2}$
Coarse gravel	$1\frac{3}{4}$–$3\frac{1}{2}$	$1\frac{3}{8}$–$2\frac{3}{4}$
Cobbles	$3\frac{1}{2}$–$7\frac{1}{2}$	$2\frac{3}{4}$–6

This material was hauled two miles by Standard railroad to a reloading station at the mouth of the canyon, where it was stockpiled

[1] Low Heat Cement for Dams. Samuel B. Morris, *Journal*, 25: 10, October, 1933.

[2] Heat of Solution Method in the Calorimetry of Portland Cement. R. W. Stenzel and S. B. Morris. Industrial & Engineering Chemistry, 6, page 246, July 15, 1934.

over an endless conveyor belt which raised it into bins from which it was drawn through manually controlled gates into one yard tramway buckets.

An aerial tramway two miles in length with capacity of 160 cubic yards per hour carried the aggregate to the concrete mixing plant at the top of the right abutment of the dam, where the one yard buckets were automatically dumped into storage bins over the mixers. The tramway had 15 timber towers including the two terminal towers and one double tension intermediate tower where there was a horizontal angle of 28°. The load track cables were 1⅝-inch locked coil type, and the return track cable was 1 inch. The traction line was 1-inch lang lay hemp center wire rope. The traction line had to be replaced once during the hauling of one million tons of aggregate but the load lines required no replacement. A 150 horsepower variable speed slip ring motor drove the one inch hauling line at the rate of 500 feet per minute.

The aggregate was drawn by gravity through manually controlled air operated gates into accumulative four yard weighing hoppers. Cement was automatically weighed in separate hoppers. Water was measured by automatic meters. The concrete was mixed in two four cubic yard tilting mixers and automatically timed three minutes in the mix before dumping onto 50-foot conveyor belts which discharged the concrete into four cubic yard straight side, bottom dump buckets placed in position by an industrial gasoline-operated locomotive and flat car operating on a shuttle track.

Two 2½-inch high line cableways 1,000 feet long with one fixed head tower 100 feet in height, and two tail towers each rolling on separate four rail tracks on the same roadbed 400 feet in length handled the placing of the concrete in all parts of the dam. It was necessary to rehandle the buckets with a stiffleg derrick in placing the extreme downstream toe of the dam below the flood release outlets. The cableways and buckets were operated by 350 horsepower electric hoists manually controller by blind hoistmen receiving instructions by electric signal or telephone from signal men located in a crows nest in full view of all parts of the dam. The cable speed was 1200 feet per minute giving a lifting and lowering speed with four part line of 300 feet per minute. The tail towers operated at 150 feet per minute by remote control in the hands of the hoistmen at the head tower.

The two cableways were able to handle the buckets faster than the

mixers could deliver the batches which at the fastest time was three minutes and 20 seconds per four cubic yard batch by each of the two mixers.

The plant was designed to deliver 1500 cubic yards of concrete in two eight hour shifts. The best record was slightly over 2,000 cubic yards in two shifts and 60,000 cubic yards in one month.

Buckets of concrete were not dumped until they were within two feet or less of the concrete surface. Operation of the buckets was perfected so that they were wholly self closing.

All mass concrete was placed by means of both internal and platform external electrical vibrators.[3] In general a concrete placing crew consisted of eight men including the foreman. Very little shoveling of concrete was required except at forms. Three internal vibrators operated by one man each and one external platform vibrator with two men were generally employed in placing concrete which had a slump of less than one inch.

Vigorous wire brushing was given the surface of the concrete within six to eight hours after placing to remove what little laitance there was and to give more effective bond. Grout was brushed into the surface of all old concrete just prior to placing fresh concrete.

While use of concrete chutes was not permitted in placing of mass concrete in the dam, they were used in placing concrete in the spillway and in the concrete lining of the right abutment. In the latter case concrete buggies were used to move the concrete each way from a chute which carried the concrete to points about in the center of distribution for the lining. Concrete was mixed in the main mixing plant and carried by truck to the head of the chutes, although some of the concrete was hauled in cars to the highest elevations at the spillway bridge.

In pouring the concrete lining a cantilever form was used, which, anchored to the previous day's pour, could be effectively used in making a 5-foot pour every day.

CONCRETE CONTROL

Very rigid concrete control was maintained and continuously checked by laboratory tests. The weights of cement and all aggregates and the water meter setting were determined and set by inspectors at the mixing plant. Tests of moisture in sand and pea gravel

[3] Vibrating Concrete at Pine Canyon Dam. S. B. Morris and Ross White, Journal Amer. Conc. Institute, 5: 4, March–April, 1934.

were made on about 20-minute intervals and curves plotted showing trends in moisture content for which adjustment was made in the water meter setting.

Samples of concrete were taken twice each shift from which one 14 by 28-inch cylinder with full sized aggregate was made and two 6 by 12-inch cylinders with all aggregate coarser than 1½-inch screened out.

A typical mix for mass concrete in dam is as follows:

4.00 cubic yard batch, weight 156 pounds per cubic foot

Cement-water ratio		1.68
Cement		0.95 barrels per cubic yard
Sand	27%	3912 pounds (dry)
Pea gravel	21%	3043 pounds
Medium gravel	10%	1449 pounds
Coarse gravel	17%	2463 pounds
Cobbles	25%	3623 pounds
Total aggregate	100%	14,490
Cement		1,429
Water (c/w = 1.68)		851
Water, absorbed		78
Batch weight		16,848

For ten feet at the upstream face of the dam 1.10 barrels of cement per cubic yard and cement-water ratio of 1.85 was used to give a more impervious concrete.

CONCRETE TESTING LABORATORY

A complete concrete testing laboratory was maintained at the dam site where all physical testing of concrete and cement was carried out. A 600,000 pound hydraulic testing machine broke 14 by 28-inch cylinders with full sized aggregate. The strengths attained with the full sized aggregate were about 20 percent less than for 6 by 12-inch cylinders with all over 1½-inch aggregate screened out.

SPECIAL STUDIES AND INVESTIGATIONS

Special studies are being carried out which cannot be discussed here, but which it is hoped will lead to additional information upon the distribution of stresses in large concrete gravity dams.

Seven uplift cells have been placed on the contact line between

concrete and the lowest part of the rock foundations. Other uplift cells were placed within the concrete itself.

Resistance thermometers have been placed in the rock beneath the contact line and within the mass concrete.

A large number of Carlson strain meters were placed throughout one block 50 feet above bedrock and about 100 feet above bedrock. Several strain meters have been incased in blocks of concrete in the interior mass free from the surrounding mass concrete for comparison with those under stress. Through coöperation with the United States Bureau of Reclamation cement and aggregates have been shipped to Denver where a number of concrete blocks with imbedded Carlson strainmeters are being subjected to the same time-temperature loading conditions as those in the dam in an attempt to distinguish between flow of concrete and stress.

In addition a great many strain plugs were placed on 20-inch centers in the vertical face of a joint in the dam, in galleries, and in the faces of the dam.

Numerous tests were made to indicate constancy of volume for the several cements obtained from the four Southern California mills furnishing cement for the dam.

Glass tubes with silvered interior were developed for use in determining the depth of cracks formed in the mass concrete. By imbedding such glass tubes about five feet in length at varying depths where cracks are likely to occur, we have been able to detect the existence of such a crack by the broken silver lining opening an electric circuit.

Photo-elastic studies of intensity and distribution of stress by use of polarized light and thin bakelite sections of the dam, and foundations were made by Dr. Brahtz under supervision of Dr. Th. Von Karman at the California Institute of Technology. These studies will be later compared with mathematical analyses, the strain studies being made on the dam itself and deflections as determined by the use of a precise theodolite.

36-INCH STEEL PIPE LINE TO PASADENA

A 36-inch all welded steel pipe line 18.5 miles in length conveys the water from Morris Dam to the Sunset and Wilson Reservoirs in Pasadena. About one mile of this pipe line is in tunnel laid on concrete piers.

All of this pipe was fabricated in 30 foot lengths with one longi-

tudinal seam, and automatically welded by the shielded arc process. Wherever practicable two lengths were welded together in the shop giving a 60 foot laying length. All of the pipe was dipped in a filled asphaltic dip in a vertical kettle providing a coating both inside and out of $\frac{1}{16}$-inch minimum thickness. In addition 23,000 feet of this pipe was wrapped with asbestos pipe covering.

The pipe was laid in general to a 3 to 4 feet cover. However in the several stream crossings, it was laid to a 10 to 15 feet cover. Much of the distance was in public streets.

For heads up to 400 feet $\frac{1}{4}$-inch plate was used corresponding to a stress of 12,500 pounds per square inch. For higher heads $\frac{5}{16}$-inch plate was used.

The pipe line has a gravity capacity of 27.4 cubic feet per second corresponding to a "C" in the Williams-Hazen formule of 138.

THE AZUSA HYDROELECTRIC PLANT

In order to construct the Morris Dam it was necessary to purchase the Azusa Hydroelectric Plant and 1000 acres of land containing the dam site itself, from the Southern California Edison Company, Ltd. The six mile conduit of 90 second feet capacity passes through the dam and reservoir site.

The conduit was composed of tunnels, flumes and rubble covered wood stave pipe. In order to make the conduit reasonably safe to withstand flooding within the reservoir to a maximum depth of 15 feet, approximately $100,000 was expended in relocating and reconstructing certain sections involving the construction of 1854.5 feet of concrete lined tunnels, 474.6 feet of 54-inch welded steel pipe, 431 feet of 54-inch centrifugally cast concrete pipe, and 122 feet of concrete box flume.

At the left abutment of the dam an emergency intake was incorporated in the construction of the dam by which water up to 90 second feet may be released from the Morris Reservoir at high stages or be spilled into the reservoir at low stages of the reservoir.

SUMMARY OF MAJOR QUANTITIES, MORRIS DAM

Concrete, cubic yards:	
Mass concrete in dam	446,000
All other concrete in dam	68,000
Total	514,000
Excavation, cubic yards	611,000

Grout holes, feet	43,800
Pressure grouting, cubic feet	38,300
Cement, barrels	580,000
Reinforcing steel, pounds	4,715,000
Outlet pipes, pounds	766,000
Outlet gates, valves and specials, pounds	1,210,000
Spillway drum gates and operating mechanism, pounds	1,447,000
All other metal work, pounds	1,023,000
Total steel and metal work, pounds	9,161,000

COST OF PROJECT

The summarized costs of the San Gabriel Project are as follows:

	dollars
Dam and appurtenances	4,850,000
Reservoir lands and rights of way including Azusa Hydro Plant	1,100,000
Roads	525,000
Clearing and sanitation	50,000
Pipe line to Pasadena	850,000
General expenses	225,000
Total	7,600,000

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

On November 23, 1932, the City of Pasadena entered into an agreement with the Metropolitan Water District of Southern California by the terms of which the Morris Dam and Reservoir are to be sold to the District for use as a terminal reservoir for the Colorado River Aqueduct when water from the Colorado River is available for delivery to Pasadena. The City being a part of the Metropolitan Water District desired to decrease its capital investment for water supply purposes, believing the Colorado River supply in addition to its local supplies will make unnecessary the retention of the San Gabriel Supply after the Colorado River Aqueduct is completed.

Entering into this contract after the contracts were awarded for the dam, made it necessary to redesign the outlets to provide for a capacity of approximately 500 cubic feet per second for the District's needs.

PERSONNEL

The San Gabriel Project including the design and construction of the Morris Dam was under immediate charge of the writer as Chief

Engineer and General Manager of the Pasadena Water Department. Louis C. Hill, Fred A. Noetzli, and A. L. Sonderegger were consulting engineers, and Dr. Frederick L. Ransome, consulting geologist. Claude W. Sopp was responsible for hydrographic studies, Cecil E. Pearce was Designing Engineer and Verne L. Peugh, Construction Engineer. Ralph W. Spencer was Resident Engineer and Ivan Tyler and Fred Chapman, Assistant Resident Engineers. (Ross White was Construction Engineer until September, 1933.)

H. Stanley Bent was General Manager for the contractors, Bent Bros., Inc., Winston Bros. Company and Wm. C. Crowell. L. T. Grider was General Superintendent and Ed M. Whipple, Assistant Superintendent.

THE BOUQUET CANYON DAM AND INLET-OUTLET PIPE

By W. W. Hurlbut

(Engineer of Water Works, Bureau of Water Works and Supply, Los Angeles, Calif.)

The present Los Angeles Aqueduct System, completed in 1913, collects water from the mountain streams that flow from the easterly slope of the Sierra Nevada Mountains, at points from 175 to 275 miles north of the city. An extension of this system, known as the Mono Basin Project, is now under construction. This project includes a collection system and a spring runoff storage reservoir located at Grant Lake, in the drainage area tributary to Mono Lake. A 12-mile tunnel is being constructed to convey the water from this drainage area to the head waters of the Owens river. The water will then flow in the river to a new storage reservoir in Long Valley, from which point it will again flow in the river until intercepted by the Aqueduct. The present Aqueduct has been reconditioned, principally by smoothing the interior surface for about one-third its length, in order to deliver the increased quantity of water that will be available. It is anticipated that a continuous flow of 450 cubic feet per second can be delivered to Los Angeles when the Mono Basin Project is in operation. Additional reservoir facilities, sufficiently close to Los Angeles to serve as terminal storage, were required in connection with this program of increased water supply.

The best location for this storage was determined to be in Bouquet Canyon, lying about 3½ miles easterly of the present Aqueduct, and at the proper elevation above the San Francisquito Canyon power plants to serve for power regulation as well as water storage. The storage capacity is 38,800 acre feet, 36,500 of which are available for use; this is sufficient to provide for 40 days flow in the Aqueduct at 450 c.f.s.

The reservoir is connected with the present Aqueduct by 3½ miles of 80- to 94-inch diameter, all electric welded steel pressure pipe, and an eight foot, reinforced concrete lined, pressure tunnel 1120 feet long.

The use of a single pipe line to serve as an inlet and outlet to the

reservoir is unique. The water is delivered by the Aqueduct to Fairmont Reservoir, which is kept full for emergency storage, and to maintain as high a head as possible in the penstocks leading to San Francisquito Power Plant No. 1, to which it is connected by a nine mile pressure tunnel. This power plant is used primarily for the generation of peak power, the tunnel and penstock system being designed to deliver 1000 c.f.s.

Water can now be delivered to the penstock from both Bouquet and Fairmont reservoirs, approximately 400 c.f.s. flowing from Bouquet Reservoir and 800 c.f.s. flowing from Fairmont Reservoir, with

FIG. 1. CITY OF LOS ANGELES. AQUEDUCT SYSTEM

the result that the Power Plant can use 1200 c.f.s. of water with a pressure head about 30 feet greater than that previously available at a flow of 1000 c.f.s. This demand, of course, exists only during the hours of peak power consumption. The Power Plant is practically shut down during the off peak hours, during which time approximately 300 c.f.s. can flow from Fairmont reservoir to Bouquet reservoir, the difference in elevation between the reservoirs being 41 feet when both are full, which is the normal operating condition. The flow of water to, or from, Bouquet reservoir is controlled by 84-inch butterfly valves, located adjacent to the penstocks, and operated by remote control from the power house.

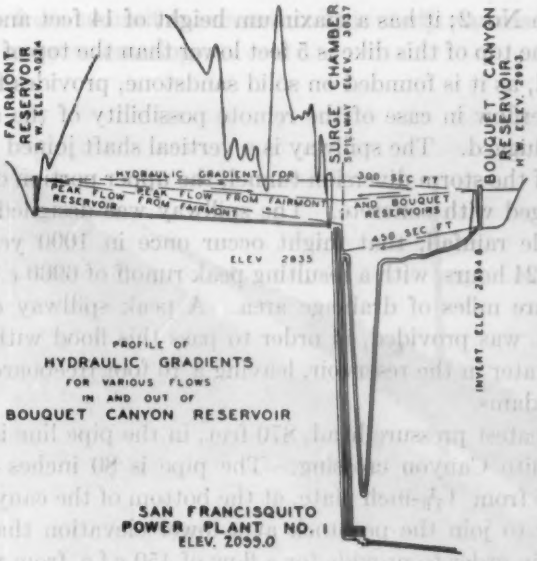

FIG. 2

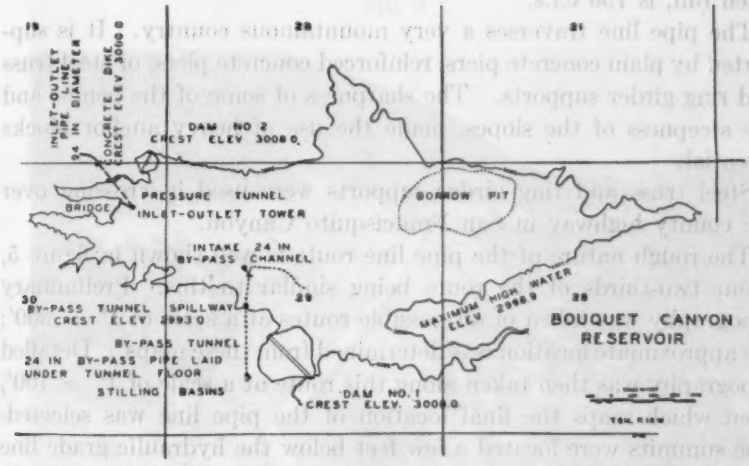

FIG. 3

Dam No. 1 is an earthfill structure 221 feet high, containing 2,876,000 cubic yards of earthfill. Dam No. 2 is a similar structure 48 feet high, containing 136,000 cubic yards of earthfill.

A gravity type, concrete dike was constructed along a low ridge

near Dam No. 2; it has a maximum height of 14 feet and is 305 feet long. The top of this dike is 5 feet lower than the top of the earthfill dams and, as it is founded on solid sandstone, provides for an emergency overflow in case of the remote possibility of the spillway becoming plugged. The spillway is a vertical shaft joined to the lower portion of the storm diversion tunnel, the upper portion of the tunnel was plugged with concrete. The spillway was designed to care for a probable rainfall, that might occur once in 1000 years, of 10.5 inches in 24 hours, with a resulting peak runoff of 6900 c.f.s. from the 13.6 square miles of drainage area. A peak spillway discharge of 1610 c.f.s. was provided, in order to pass this flood with a five foot raise of water in the reservoir, leaving a 10 foot freeboard at the two earth fill dams.

The greatest pressure head, 870 feet, in the pipe line is at the San Francisquito Canyon crossing. The pipe is 80 inches in diameter and made from $1\frac{1}{16}$-inch plate, at the bottom of the canyon. It was necessary to join the penstock at a lower elevation than the surge chamber in order to provide for a flow of 450 c.f.s. from the reservoir when it is nearly empty. The maximum outflow from the reservoir, when full, is 750 c.f.s.

The pipe line traverses a very mountainous country. It is supported by plain concrete piers, reinforced concrete piers, or steel truss and ring girder supports. The sharpness of some of the bends, and the steepness of the slopes, made the use of heavy anchor blocks essential.

Steel truss and ring girder supports were used in crossing over the county highway in San Francisquito Canyon.

The rough nature of the pipe line route is well shown in figure 5, about two-thirds of the route being similar to this. Preliminary topography was taken of all possible routes at a scale of $1'' = 500'$; the approximate location was determined from these maps. Detailed topography was then taken along this route at a scale of $1'' = 100'$, from which maps the final location of the pipe line was selected. The summits were located a few feet below the hydraulic grade line required for a flow of 450 c.f.s. from the lower level of the reservoir. The location of the pipe at lower elevations would have resulted in greatly increased cost, due to the necessity for thicker plate to withstand the resulting increased pressure. It was found more economical to cross the canyon in the foreground by swinging to the left and reducing the thickness of the steel plate rather than a straight

line location from summit to summit. This study was made for each of fourteen canyon crossings.

FIG. 4

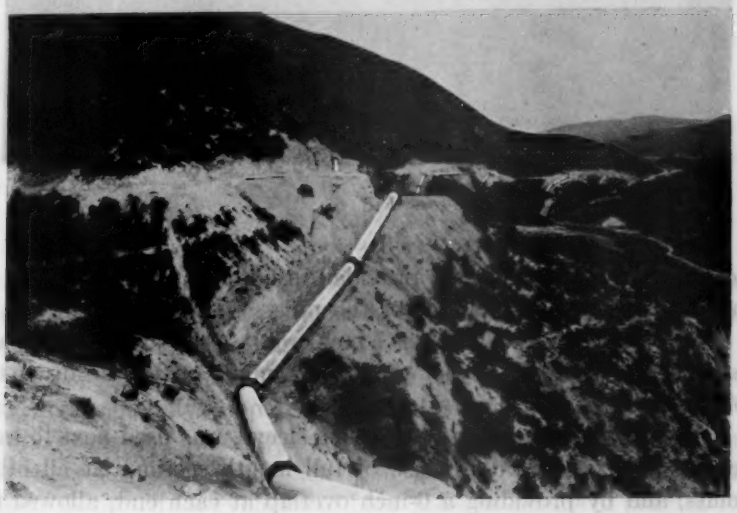

FIG. 5

Anchor blocks are provided at each bend to resist the resultant pressure thrusts and to hold the pipe in place when empty. The

maximum longitudinal tension or compression in the steel resulting from temperature changes when empty will be approximately 10,000 pounds per square inch. The anchor blocks are held in place by steel rods grouted into holes drilled in rock.

Small canyons were crossed by the use of trestle and ring girder supports. These and all other structures in the project were designed for a seismic coefficient of one-tenth.

The field joints were made by the use of a split butt strap wherever the plate thickness exceeded $\frac{5}{8}$ inch. A 60° "V" opening for butt

FIG. 6

welding from the inside was provided in addition to the welding of the butt strap to the outside of the pipe.

Where the plate thickness was $\frac{5}{8}$ inch or less, a slip joint was formed as shown in figure 7. Fillet welds were made on the inside of the joint as well as on the outside.

A long outside butt strap or closing sleeve, was used next to each bend. This permitted the use of full length sections at all other points, and by providing a 6-inch overlap at each end, allowed for the adjustment of any accumulated errors in pipe length. The steel is structural grade, A.S.T.M., A-78-30, Grade B. A maximum circumferential stress of 13,500 pounds per square inch was used in the

design. The pipe was fabricated in 20 to 30 foot sections in order to keep the maximum weight of a section below ten tons. All sizes were fabricated by the use of three longitudinal machine welded seams, rather than the use of shorter sections and more frequent circumferential joints. The machine welding was very rigidly inspected. The correct values of: depth of flux, voltage, amperage, and speed of carriage travel were determined upon test specimens before the start of the work and a continuous check was kept of these items. Two to five passes were required to complete the weld.

FIG. 7

The test specimens were used for tension, cold bend, nick break, and acid etch from a specimen cut from a completed section of 80-inch pipe made from $\frac{3}{4}$-inch plate.

Test specimens were cut from the finished pipe in some cases, but were generally prepared by welding coupons to the end of a pipe section and making a continuous weld along both pipe and coupon. The surface of each weld pass was cleaned of flux and closely inspected for evidence of blow holes or defects of penetration, after which the weld metal was peened and the next pass applied. All observable defects were remedied by immediate chipping and rewelding.

All of the straight pipe sections which were made from steel plate of $\frac{5}{8}$ inch or more in thickness and all of the bend sections were stress relieved in an oven at a temperature of 1225° for one hour per inch of plate thickness.

Each section of pipe was numbered and fitted to the adjacent sections at the point of manufacture. They were then shipped to a receiving yard, in the proper order for assembly.

All of the pipe was sandblasted, inside and outside, at the receiving yard. A machine was used for sandblasting most of the straight sections, but some of these, and all of the bends, were sandblasted by hand.

The sections were primed inside and outside to within a foot from both ends, where the priming coats were omitted until the field welding was completed. The outside priming coat was a phenol-resin base red lead, selected because of its durability and low heat absorption from sunlight, an important factor in the construction of a long, electric welded, pipe line. A white second coat was followed by a final coat of aluminum; both were of the phenol-resin base type.

The pipe sections were enameled at the receiving yard to within one foot of both ends. The enamel was selected after exhaustive tests of all known types. These tests included: resistance to water absorption under pressure, strength of bond to steel plate, resistance to sag at 150°F., and resistance to cracking at 0°F.

All of the enameled sections were checked for defects in coating thickness by the use of a fine wire brush to which was applied the potential from a Ford spark coil, adjusted for a spark length of $\frac{3}{8}$ inch between wire ends. The penetrating spark could be seen and heard at all points where the coating thickness was less than $\frac{1}{32}$ inch. This spark test was repeated after the pipe was installed, after the portions adjacent to the welds had been enameled, in order to locate and repair any cracking or chipping of the enamel that might have been caused by construction operations and to check the application of the enamel over the field welds.

The pipe sections were hauled by truck to the top of each slope, securely chained in this specially constructed carriage, and lowered into place by means of a track constructed by laying rails on either side of the concrete piers. The piers were constructed 2 inches below grade except that the center portion of each pier was constructed to grade, in order that the pipe could be placed in its final position before welding. Concrete mortar was tamped between the empty

pipe and pier after the welding was completed. The pipe was found to be more out of round when filled with water under a few feet of head than when empty or under working pressures.

The track for the pipe carriage was also used for conveying concrete to the piers. It was found to be economical to excavate to greater depths than usual, with consequent reduction in the height of the concrete piers, because of the low cost of excavation by tractor and bulldozer. On the steeper slopes, such as the one across the canyon, the tractor and bulldozer were assisted to travel uphill by means of a steel cable attached to a hoist and tractor stationed at the top of the hill.

The pipe sections were lowered until they came in contact with the previously laid section, after which safety cables that passed through the pipe section were unhooked, the hold-down chains released, and a choke-line and tackle attached to the pipe. The section was then moved uphill about 4 inches, by use of the small hand winch and choke-line, with the carriage remaining in position, after which either end of the pipe could be raised or lowered as necessary to work it into place.

Ladder sections were attached to each pipe section by welded brackets near the end. Platforms for the welders were attached to the ladders that permitted easy access to all parts of the circumference for welding. $\frac{3}{16}$- and $\frac{7}{32}$-inch coated electrodes were used for field welding, 125 welders were examined before the required 27 were found who could qualify for A.S.M.E. class 2 welding in an overhead position.

BOUQUET DANYON DAM NO. 1

Bouquet Canyon Dam No. 1 is built on a foundation of schist of all degrees of hardness. Practically all of the foundation is crisscrossed with minor faults that are filled with gouge. Preliminary exploration disclosed this condition of rock and a very liberal cross-section was selected because of this feature. The reservoir has now been filled for several months and the abutments are very watertight, there being only one point at which evidence of leakage is observable. This leakage has been collected in a drain and amounts to only a few drops per minute.

The distinctive features of the design of this dam are the stripping to bedrock of the upstream two-thirds of the foundation, and the liberal cross-section; a 50 foot crest width and 3 to 1 side slopes

having been provided. Care was taken in the construction of the pervious fill to place rocky and free draining materials next to the abutments in order to prevent saturation of this portion of the dam. The construction of the compacted earthfill was controlled by new methods that have been developed in the past five years by the Bureau of Water Works and Supply. This method is principally a control of the moisture in the soil at the time it is compacted on the dam. An investigation of the effectiveness of sheepsfoot rollers of various types was also made and resulted in the use of considerably heavier equipment than that ordinarily in use.

The foundation was stripped to firm bedrock immediately before placing the rolled earthfill and the removed soil and rock was placed in the pervious downstream section of the dam. Forty-five feet of

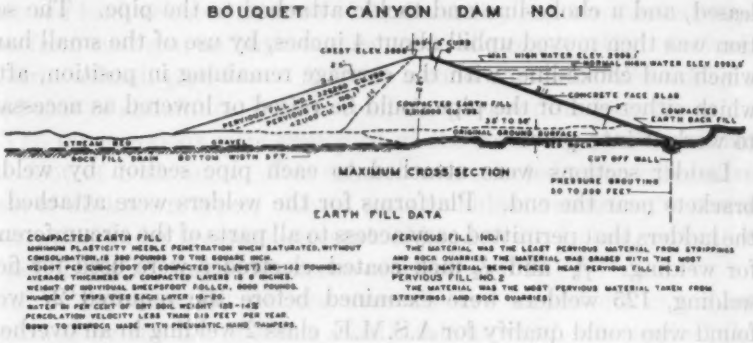
BOUQUET CANYON DAM NO. 1
CREST ELEV 2006.0
MAX HIGH WATER ELEV 2004.1
NORMAL HIGH WATER ELEV 2003.6
PERVIOUS FILL NO.2 275000 CU YDS
PERVIOUS FILL NO.1 425000 CU YDS
COMPACTED EARTH FILL 2,250000 CU YDS.
CONCRETE FACE SLAB
COMPACTED EARTH BACK FILL
2½ TO 1
STREAM BED
GRAVEL
ORIGINAL GROUND SURFACE
ROCK FILL DRAIN
BOTTOM WIDTH 8 FT.
CUT OFF WALL
MAXIMUM CROSS SECTION
PRESSURE GROUTING 50 TO 200 FEET
EARTH FILL DATA
COMPACTED EARTH FILL
MINIMUM PLASTICITY NEEDLE PENETRATION WHEN SATURATED, WITHOUT CONSOLIDATION, IS 200 POUNDS TO THE SQUARE INCH.
WEIGHT PER CUBIC FOOT OF COMPACTED FILL (WET) 130-142 POUNDS.
AVERAGE THICKNESS OF COMPACTED LAYERS IS 6 INCHES.
WEIGHT OF INDIVIDUAL SHEEPSFOOT ROLLER, 8000 POUNDS.
NUMBER OF TRIPS OVER EACH LAYER 10-20.
WATER IN PER CENT OF DRY SOIL WEIGHT 10.5-14.5
PERCOLATION VELOCITY LESS THAN 0.13 FEET PER YEAR.
BOND TO BEDROCK MADE WITH PNEUMATIC HAND TAMPERS.
PERVIOUS FILL NO. 1
THE MATERIAL WAS THE LEAST PERVIOUS MATERIAL FROM STRIPPINGS AND ROCK QUARRIES. THE MATERIAL WAS GRADED WITH THE MOST PERVIOUS MATERIAL BEING PLACED NEAR PERVIOUS FILL NO. 2.
PERVIOUS FILL NO. 2
THE MATERIAL WAS THE MOST PERVIOUS MATERIAL TAKEN FROM STRIPPINGS AND ROCK QUARRIES.

FIG. 8

gravel and loose rock were removed for the concrete cut-off wall at the upstream toe. This wall was varied in width from 3 to 4 feet and extended from 10 to 20 feet into the bedrock. The pipes projecting from the trench were placed before the concrete was poured to serve as starters for drill holes for bentonite-cement mixture pressure grouting. These holes were drilled from 50 to 200 feet below the top of the concrete but-off wall, depending on the nature of the rock. The cut-off wall was excavated and grout pipes installed along the entire upstream toe of the dam, extending up both abutments to the crest, 1043 cubic yards of grout being forced into the foundations of the two dams.

The foundation for the compacted fill was cleaned to bedrock. Contact of the fill to the bedrock was insured by the use of pneu-

matic tamping tools at all points that could not be reached by the sheepsfoot rollers.

The foundation was progressively stripped as the fill was made, the materials removed being placed in the pervious section of the dam.

The proposed borrowpit areas were explored with a drill at intervals of about 200 feet. Representative soil samples were taken for each 5 feet of depth.

Representative soil samples from various portions of the proposed borrowpits were analyzed by a new method. The soil densities secured by compating one soil at different moisture contents are shown in figure 9. It will be noted that this particular method of compaction secures a maximum density in this soil, with a consequent minimum of voids, and percolation rate, when the soil is compacted at slightly over 12 per cent moisture content. A similar critical moisture content can be found for most soils.

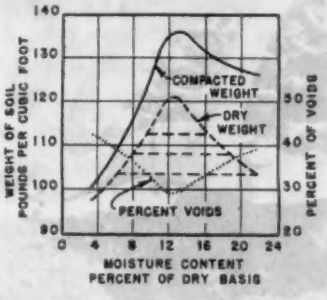

FIG. 9

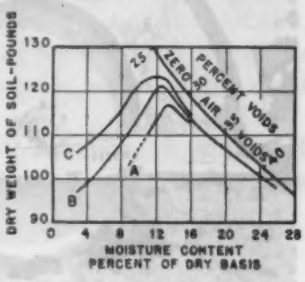

FIG. 10

The results of experimental data to determine the weight of rollers required for a typical Bouquet Project soil are shown in figure 10. Curve "A" shows the results of experimental field compaction using a customary light weight sheepsfoot roller. Curves "B" and "C" were prepared in the laboratory and sheepsfoot rollers were designed to duplicate the results shown on Curve "C." It was found that the soil density required for sufficient stability of the soils when saturated was greater than that required for watertightness.

The roller shown in figure 11 was designed and constructed in the shops of the Bureau of Water Works and Supply. Each single drum weighed 8000 pounds and exerted a pressure on the soil of approximately 155 pounds per square inch when operated at the depth of tooth penetration shown, that is, about 3 inches. The surface shown

is typical of that left by the rollers after the required sixteen trips had been made.

The borrowpit soils were thoroughly mixed by the excavation methods used. The bank was broken down by hoisting the open bucket along the entire face, after which the trucks were loaded from the mixed soil at the bottom of the bank. This was also found to be the cheapest method of excavation, as much more power was available for breaking down the bank when the unfilled bucket was hoisted for this purpose, than when the bank was broken down by hoisting the filled bucket, as is often done.

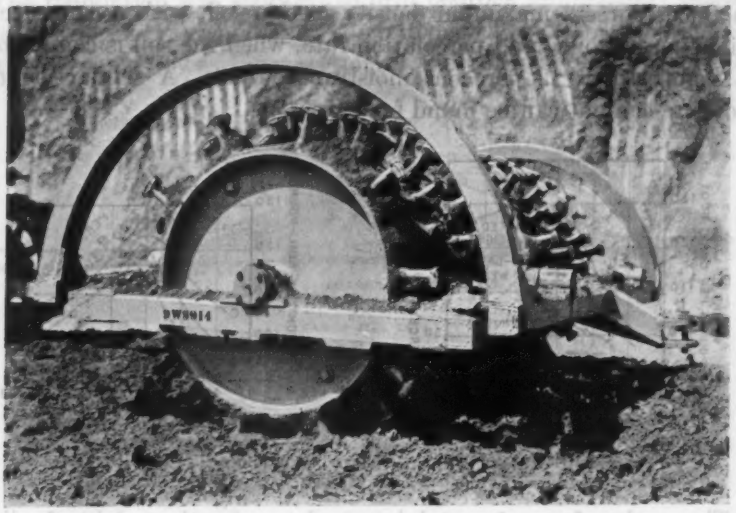

FIG. 11

From five to six roller units were used. These traveled in loops until the required number of trips over one point had been made, after which an additional loop was started. Additional roller loops were made approximately parallel to the abutment in order to insure against omissions from turning.

Frequent measurements of the density of the compacted fill were made by boring holes about 8 inches in diameter and 12 inches deep in the compacted fill. The removed soil was carefully weighed and the volume of the hole was measured by filling it with the fine dry beach sand. The weight of sand used to fill the hole was determined

by weighing the sand and container before and after filling the hole. This sand was found to have a weight that was constant within ½ pound per cubic foot when poured in a container without tamping. The soil density thus determined was compared with that determined by laboratory methods and, where found deficient, additional rolling was required until the necessary soil density was attained.

The dams were protected from erosion by a continuous reinforced concrete face slab, without expansion joints, from 6 to 9 inches in thickness. The size of shrinkage cracks was limited to approximately 0.02 inch by the use of 0.5 per cent of intermediate grade reinforcing steel, in both directions. This amount of steel has sufficient strength to crack the concrete in the slab before the elastic limit of the steel is reached, resulting in frequent small cracks in the concrete rather than a concentration of shrinkage at less frequent points, with resulting cracks of sufficient width to permit erosion of the soil below the concrete by wave action.

A reinforced concrete gate tower was provided at the end of the inlet-outlet tunnel and fitted with five 3½ feet by 5 feet sluice gates. A 200 foot span suspension bridge provides access to the control gates from the shore.

The maximum settlement of Dam No. 2 to date, 18 months after completion, has been 0.01 foot. Dam No. 1 has settled a maximum of 0.22 foot in the same period.

CURRENT SITUATION IN THE PUBLIC WORKS PROGRAM

By Malcolm Pirnie

(*Consulting Engineer, New York, N. Y.*)

Becalmed on a sea of the greatest potential construction demand that has ever existed in this country, the Public Works Program drifts with money, money every where and not a dollar to stimulate construction volume. More than one and a half billion dollars of the original P. W. A. fund remain to be expended, which means that five and a half billion dollars are now appropriated for various classes of future work.

In two full years since the signing of the National Industrial Recovery Act at the time of our Chicago Convention $2,225,000,000 have been spent.

Allotments		*Expenditures*
From $1,100,000,000 for Executive and Legislative Allotments listed as follows		$922,000,000
Farm Credit	$100,000,000	
T. V. A.	50,000,000	
C. C. C.	322,600,000	
N. R. A.	4,900,000	
C. W. A.	400,000,000	
F. E. R. A.	1,500,000	
Subsistence Homesteads	25,000,000	
Public Works	100,000,000	
Balance of P. W. A.	100,000,000	
From $1,369,000,000 alloted for Federal projects including $405,015,000 Public Roads		888,000,000
From $627,000,000 alloted for Non-Federal, State and Municipal Works, later increased to $750,000,000		232,000,000
From $193,600,000 alloted to Railroads		160,500,000
Total		$2,202,500,000
If we deduct from this:		
Farm Credit		$100,000,000
C. C. C.		322,000,000
Allowance for P. W. A. and N. R. A. Administration estimated at		60,000,000
And C. W. A. made work		400,000,000
Total		$882,000,000

Two years of expenditures on construction projects are approximately	$1,320,000,000
Or at the average yearly rate of	660,000,000

This is an annual expenditure of not more than 100 million dollars above the record year for Federal expenditures under the Hoover administration, and may be accounted for in the 232 million dollars expended by states and municipalities.

What has happened to expand the ability of the Federal Government to direct construction in excess of 500 million dollars per year? Nothing that has been established in the past two years or that has been announced since the passage of the Works Relief Act. Another board has been appointed to sift projects that have weathered the 10 to 18 months storm in P. W. A., or that may be presented by other agencies. How long will it take for projects to clear through this new investigation? Speed must be accelerated to 500 per cent of former performance, if five and a half billion dollars are to be spent in the next two years.

Public Works Administration procedure with its assumption of complete supervision of all projects cannot speed up the work even if the grant should be increased and the interest rate on the loan decreased. The only alternative if Federal supervision is continued is a huge Civil Works Administration type of made work relief activity. Our political subdivisions will not obligate themselves to reimburse the Federal Government for the cost of structures created in this inefficient manner. They are avoiding any increase in their debt burdens in spite of the fact that they have present need for at least six billion dollars worth of new and maintenance construction. They are still going into debt with the Federal Government at the rate of nearly three billion dollars a year for relief. And at the same time private funds begging for safe investment are accumulating in the banks in huge sums, possibly between eight and ten billion dollars.

Here is the problem stated in round numbers: 9 billion dollars private cash needing safe investment; 6 billion dollars worth of needed public works; 12 billion dollars worth of needed housing, factory and private utility renovation and construction; 3 billion dollars annual cost of relief; 3.5 million employable persons on relief rolls; and 5.5 billion dollars Federal appropriation for Works Relief.

Unemployment of investment dollars are responsible for continuing unemployment of employable persons. The money to convert the 5.5 billion dollars Federal appropriation into cash must be drawn from the 9 billion dollars of private cash. If spent on a gigantic Civil

Works Administration type of activity the surviving private agencies will be smothered largely into non-existence, so that when the money is gone normal activities will be too thoroughly disrupted to resume their proper place in the economic scheme. A way must be found to create incentive for revival of normal activities in continuing the building of the national wealth.

Can our states, counties and municipalities be trusted to determine what they need in the form of public works, to plan and execute them? They have done so more or less efficiently so long as they have existed without Federal dictation until two years ago. Are they not ready to resume normal practices if given the necessary incentive?

Suppose the President were to ask the communities of the nation to start immediate normal planning and construction of their most needed public works, requiring only a state board approval of the project filed with estimate of cost, and agree to reimburse each community for expenditures made for planning, supervision, labor and materials 50% of expenditures made prior to December 31, 1935, 30% of expenditures during the following nine months and 20% of expenditures during the balance of the works program. Would not most of the communities that can issue bonds undertake needed works at such bargain cost? The materials and equipment they purchased would reopen factories, supply yards and warehouses, and increase transportation tonnage to reemploy substantial numbers of workers in the industrial centers. The urge to make the major part of the expenditure for the project eligible for the 50% reimbursement would flood materials manufacturers with orders and require contractors to operate on two and three shift work.

If under this plan three billion dollars worth of work could be done at an average Federal reimbursement of 40 percent.

Federal Funds required would be	$1,200,000,000
Bond Issue Funds required would be	1,800,000,000
New direct and indirect employment in the first year would be	1,400,000
This is 40 percent of the 3,500,000 employable on relief rolls	
Possible saving in relief expense	1,200,000,000
Such saving equals the Federal contribution to the program.	

There would be left for other types of works program $4,300,000,000 of which $1,500,000,000 are already allocated to P. W. A. projects.

This leaves $2,800,000,000 for additional P. W. A. C. C. C. and modified C. W. A. activities, that can be spent in the communities unable to secure the necessary partial private financing under the suggested program of *diminishing* grants.

Water works enjoy the highest credit rating of all public Works in P. W. A., and private banking circles. More progress has been made in the last three years than in any former decade, in making the general public conscious of the financial soundness of water works. It is possible now in almost every state to issue revenue bonds for water works construction and unprecedented low interest rates are available for financially sound bond issues. The cost of normal methods of construction is substantially lower today than it will be when the close to twenty billion dollar volume of needed construction of all types gets under way. When this happens the industrial and domestic demands for water service will swing back above normal and those communities which have not adequately maintained, reinforced and extended their water properties in anticipation of the immediate future requirements will be forced to do so at high cost in competition with all other accelerated activities. Water works officials if true to their trust will plan, finance and build now to supply at least normal requirements for service in the immediate future.

We must not forget the advent of conveniences which are constantly increasing the per capita use of water, nor should we forget that the most severe drought of record over a considerable area of the country came at a time of subnormal demand for water. Let us *reappraise* all water works systems in the light of recent dry weather influences on capacity and quality of sources of supply and upward trend in per capita use. From such studies works to *correct* deficiencies should be planned and built at once, to offer excellent water service at minimum cost during the period of renewed activity which is certain to follow the depression.

Up to this minute no orders have been issued changing the P. W. A. rules and regulations. Is a 30 per cent grant and four per cent loan under their regulations attractive financing for water works construction today? Many communities are borrowing money for such construction from private banks at interest rates below 4%, and letting unhampered contracts for speedy construction of their needed works. To be free to move fast and take advantage of the present construction season is worth more than a 30 per cent grant with its accompanying delays and accounting costs. Try private financing of all

projects ready to go even if they have received provisional P. W. A. approval and if successful get this work underway at once under accustomed methods of execution. If the diminishing grant method of stimulating construction volume is offered later this resulting reimbursement can be used for additional needed construction or to retire part of the debt incurred.

Whether work is to be financed through private sources, by P. W. A. or carried out under a C. W. A. type of management, it is certain that in the average community only such work as has been planned well beyond its preliminary stages will become part of the works program.

It is common knowledge of those close to many projects submitted for government aid that they lack the care in planning that such projects usually receive. Many have been submitted based entirely upon necessarily casual studies of engineers and architects serving without compensation. The overwhelming degree of unemployment of the technically trained men during the past five years in spite of employment provided in government emergency bureaus is proof of the utter lack of preparedness to undertake now to execute a 5.5 billion dollar program of construction and expect it to be of sound economic value.

The Public Works Program to be even moderately creative of its stated purpose must first concentrate on the rapid development of sound plans. The only hope for early activity in actual construction on a large scale is in the enlistment of wholehearted coöperation of a large majority of urban communities to determine their most needed public works, to plan them adequately and to proceed according to accustomed methods to construct such works with the amount of Federal financial assistance necessary to secure this degree of cooperation.

The speaker has represented the American Water Works Association this year as First Vice Chairman of the Construction League of the United States and as Chairman of its special Legislative Committee. Following a conference with the President the League presented a document on April 17, 1935, to the various governmental agencies in Washington which may have a part in the administration of the Work Relief Program, setting forth in detail the principles and procedure for the construction industry which will revive normal functioning of construction channels. The "Foreword of Principles" in this document reads as follows:

In order to effectuate the purposes of the Emergency Relief Appropriation Act of 1935, namely, "to provide relief, work relief, and to increase employment by providing for useful projects" and also to "utilize wherever practicable the facilities of private enterprise" in the construction industry the following principles of procedure are recommended.

CLASSIFICATION:

So that the program be productive of useful works, and that waste and inefficiency be eliminated to the greatest possible degree, it is essential that the unemployed drawn from relief rolls should be put to work on projects suited to their capabilities, and at rates of pay established in accordance with the Act.

A practical accurate occupational classification of the persons to be given employment is essential to the success of the program.

To insure the selection of competent workmen for construction projects, those on relief rolls must be classified on the basis of their experience, training and skill in the several occupations provided. Each person claiming to quality for employment on construction must be subjected to examination, his employment record investigated and his competency satisfactorily demonstrated.

Closely related to and dependent upon the occupational classification of the unemployed, is the procedure for placing them in jobs. There should be only one employment service. Duplication of such service will result in confusion, and in placement of incompetents, or the duplication of enrollments.

The work relief program will be incomplete if it lacks provisions for rehabilitation of the greatest possible number who have broken under the strain of the depression and for the vocational training of the youth of the country who have never had a job. To every construction project there should be an assignment of apprentices based upon a practicable working ratio to the number of skilled mechanics employed.

Design of projects.

Type of agreements

The professional services of engineering, architectural, and landscape architectural firms should be engaged on a percentage fee basis. But where this procedure is impracticable such services may be engaged on a fee basis which should provide for payment of a per diem or weekly fee for principals and for supervisory assistants and an allowance for overhead expenses, together with the actual salaries for relief workers.

The relative competency of the workers must be left to the determination of the professional firm. The agreement should specify, that in cases of faulty classification the firm, subject to certain necessary restriction, should have the right to dismiss those drawn from relief rolls, recommend their reclassification, and draw other workers from the relief rolls in their places. In case no competent men are available on the relief rolls, workers should be obtained as far as possible from the local unemployed.

Regular employees in public agencies and private enterprises should not be replaced by persons drawn from relief rolls, nor should the work customarily performed by such agencies and enterprises be transferred to new agencies created to provide employment for relief workers.

Qualification of architects and engineers

Architects and engineers to be thus engaged on a percentage fee basis or on a weekly or daily fee basis should be properly qualified for the specific types of professional services they are to render.

Selection of architects and engineers

Selection of architects and engineers to be thus engaged should be done locally through properly constituted architectural and engineering boards whose members should be required to agree to nonparticipation in the actual work under the program, and who would be compensated on a basis of either actual expenses or time expended or both.

The members of the national and local qualification and selection boards should be appointed by the President from nominations made by the Construction Code Authority.

CONSTRUCTION CONTRACTS:

Type of contracts

All work possible should be executed under lump sum or unit price type of contracts awarded through competitive bidding by contractors. Where management contracts are deemed more feasible, due to certain conditions, a fixed fee should be used and not a fee which is based on a percentage of the cost of the work. The contracts used should provide that the contractor may employ an administrative and supervisory force of his own choosing (limited to a minor percentage of the total employees) and that other employees shall be drawn from the relief rolls when properly qualified men are available on such rolls in accordance with the terms of the Act. The contract should stipulate the wages that must be paid to each class of employee.

The relative competency of the workers and their willingness to work must be left for determination on the job. The contract should specify that in case of faulty classification the contractor, subject to certain necessary restructions, should have the right to dismiss or transfer the workers, or recommend their reclassification and draw other workers from the relief rolls in their places. In case no competent men are available on the relief rolls, workers should be obtained as far as possible from the local unemployed.

Qualification of contractors

Contractors and subcontractors on all work should be properly qualified on the basis of the codes for their respective branches of the industry.

Selection of contractors

Selection of contractors and subcontractors on competitive lump sum or unit price type of bidding is automatic.

With regard to selection of contractors and subcontractors on the management type of contract, this should be done locally through properly constituted industry boards whose members should be required to agree to non-participation in the actual work under the program, and who would be compensated on a basis of either actual expenses or time expended or both.

The members of the national and local qualification and selection boards should be appointed by the President from nominations made by the Construction Code Authority.

CONSTRUCTION MATERIALS:

The purchase of construction materials for relief work should be according to normal procedure, namely through the usual distribution channels and by contractors and special contractors. Such a procedure will preserve and enhance the existing normal system of producer to wholesaler to contractor to consumer.

However, if for certain conditions and reasons, direct bulk purchase by Government procurement offices is found to be necessary, the Government should restrict their centralized purchase to a few standard items in carload lots. The Government should also deal with an industry as a unit through its recognized trade association or code authority, and not attempt to break down by improper measures either the distribution system or the current competitive price structure.

ADVISORY:

A national advisory body, representative of the construction industry should be established by the President to aid and advise the administration in the formulation of broad policies and procedure to the extent that the work relief program utilizes construction as a means of accomplishing its purpose.

Construction League of the United States Special Committee on Work Relief Program

Approved by the *Executive Committee*
J. P. HOGAN, *Chairman*
MALCOLM PIRNIE

JOHN E. ZINK
S. F. VOORHEES
A. E. HORST
E. J. MEHREN
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S. F. VOORHEES, *Chairman*
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JOHN E. ZINK
B. R. VALUE, *Secretary*

The speaker served also on a sub-committee of another organization which is preparing a report on the whole construction field. The following extract from a joint draft of this subcommittee report is of interest to all of us.

ADMINISTRATION OF EMERGENCY RELIEF APPROPRIATION ACT OF 1935

Expenditure of the $4,880,000,000 appropriation recently authorized by Congress will be a dominating factor in construction industry operations during the next two years. According to the general outline of the program contained in the Act more than half of the total amount will be spent for building and engineering work. It is intended that those building and engineering projects shall represent environment—changing public improve-

ments that will constitute real additions to the wealth of the country, and also that wherever possible full advantage will be taken of the facilities of private enterprise.

It is very important that this program be administered in such a way as to promote a maximum of recovery and to pass the ball back to private enterprise and local governmental agencies so that the end of this program will leave the country without a serious unemployment problem, or at least a greatly diminished need for public relief. The Sub-Committee wishes to make specific recommendations as to methods of carrying out two sections of the program Non-Federal public works and housing.

Non-federal Public Works

In pre-depression years, when annual expenditures for public works were considerably greater than they have been under the National Industrial Recovery Act, 91 per cent of all such expenditures were made by states, counties, municipalities and other local government bodies which had established methods of placing and financing needed improvements. It may be safely assumed that no other category of works listed in the Act can be considered as more necessary than this one, particularly since local communities have fallen behind with their improvement program in recent years and there is a tremendous accumulation of planned projects of this kind.

Under the N. I. R. A. program the P. W. A. advanced $765,000,000 to solvent non-Federal Government agencies, such advances consisting partly of loans, partly of loans and grant, partly of grants only.

During the past year, with greatly improved conditions in the municipal bond market, local agencies which could readily finance their own requirements have preferred to take a grant without a loan from P. W. A. and supply their share of the money by raising the money in their customary manner.

About $100,000,000 was advanced by P. W. A. on the basis of grants only and this amount, being matched by $313,000,000 of local money, produced $415,000,000 of construction. There was thus established a procedure whereby the Federal Government paid a bonus to local agencies for starting their deferred improvement projects and was not obliged to act as banker for the local agency.

There has been proposed a plan of diminishing grants, which would accomplish three purposes.

1. By matching local dollars with Federal dollars, it would enable Federal outlays to be multiplied several times in volume of work produced.
2. It would put a premium on speed.
3. It would decentralize the program by placing responsibility for execution wholly upon the local communities, where it should return as soon as possible.

This plan, in brief, is as follows:

1. That non-Federal projects be stimulated, so far as possible, with grants only.
2. That the grants be offered on some such basis as the following (the figures quoted being for purposes of illustration only).
   (a) A 50 percent bonus or rebate on all expenditures made for approved projects before January 1, 1936

(b) A 30 percent bonus or rebate on all expenditures made for approved projects between January 1, 1936 and September 30, 1936

(c) A 20 percent bonus or rebate on expenditures for approved projects made after September 30, 1936.

3. That full responsibility for efficient and economical execution of the projects be placed upon the localities.

4. That simple regulations regarding approval of projects, certification of expenditures and payment of Federal grants be put into effect, in order to avoid unnecessary delays.

RECOMMENDATION: The Sub-Committee recommends that most careful consideration be given to this plan, or some modification of it, by Administration officials in charge of the works program.

The need for adopting a method of speeding up this class of work is great. If non-Federal work moves as slowly as it has under the previous P. W. A. program, there will be a likelihood of diverting funds that might be spent under this category into work relief projects, which generally are far more costly and apt to be demoralizing to the construction industry.

In conclusion, the potential status of the Public Works Program is presented in the order of influencing factors which must be attacked with intelligence and speed if the program is to be an agency for acceleration instead of retardation of recovery.

1. An insignificant volume of presently productive public works has been adequately studied and planned.

A concerted universal wave of intensive planning must precede actual initiation of construction operations.

2. The Federal Government is not organized to plan and execute constructions substantially in excess of its normal activity having peak volume of half a billion dollars a year, exclusive of the Federal aid highway service. Immediate decentralization of the bulk of the program by placing responsibility for specific planning and execution wholly upon the local communities where it should return as soon as possible is an essential requirement.

3. There is a tendency to establish new governmental agencies to plan, direct and secure materials for hastily selected works projects. Local government and private agencies exist in more or less skeleton form which handled effectively as recently as 1929 more than one billion dollars worth of construction a month. They can now be depended upon to handle a mere quarter of such volume and if not given the opportunity to do so can not live to carry on effectively when the present program ends.

4. Recovery is coming in spite of anything we do to hinder it in our feverish attempts to hasten it. With recovery will come the un-

leashing of a pent-up demand for construction, to correct deferred maintenance, offset obsolescence and provide for the needs of a five-year increment in population. This will increase construction costs substantially above present costs.

5. Private financing of water works is attractive today in a majority of the communities. Necessary work for the immediate future should be initiated at once if it is to be constructed at low cost and if it is to be eligible for possible inclusion in the public works program.

FUTURE GROWTH OF AMERICAN CITIES

By C. A. Dykstra

(City Manager of Cincinnati, O.)

The city which we have come to know is the familiar picture of a main business center, with industry adjacent to rail and water service, and in between and interdispersed residence sections. During the past few years there has been movement outward as well as further concentration. The resultant of these changes shows waste and lack of planning. Much of the old central city is blighted and dilapidated, great areas are partially developed and spotted, and the necessary public services are far-flung and scattered. Expansion has doubtless been too great and too fast, with the result that the present physical city must pay the price of over-speculation and over-building of transportation facilities. Furthermore, we must acknowledge that we have developed no urban land policy which can be defended. We have been living under the assumption of continuous growth and it now proves to be a slender reed upon which to lean. Disintegration has begun and slum areas have developed and become a charge upon the taxpayers outside the slum areas. We have come to the time when old values are being destroyed faster than new ones are being created.

Someone has described the American city as "one vast speculation in real estate." There is so much truth in the remark that it hurts a good deal. Less and less must this be true in the days that are ahead. The city cannot continue a field of exploitation if we are to have a sound urban life.

Some things we can know by analogy. The history of Europe indicates that our western populations become from 75 to 80 percent urban as they become industrialized. We may expect some such development here. In some sections of our country such an urban percentage is already attained. Nothing can be clearer, therefore, than that we can learn a good deal about city life and city tendencies by looking across the Atlantic. By this same token we are led to the conviction that we must undertake some comprehensive planning if we are to avoid the mistakes of those who traveled our road just a few

years earlier. The ready-made solution of our troubles, known as decentralization, does not take all of the factors of our problem into account. To abandon existing urban facilities and sites does not give us the answer for what is left and what shall be done with it. Some values are worth conserving even though we turn our backs on the exploits which originally laid the pattern of development.

Another point of view must always be kept in mind when we discuss the city of the future. The city, besides all else, is a *way of life* a method of living. It is a mechanism or device for getting satisfactions out of life. It faces the same problem in its planning that the individual does when he organizes his life. The individual without a purpose finds little satisfaction in living even if that purpose be as mundane as the search for financial security. The city, too, must have an objective—something to look forward to and work for if it is to be psychologically sound. In such an objective may be included comfort, beauty, happiness, or distinction in some field of joint endeavor. It is this that citizens express when they say "My city is an art center;" "a music center;" "we are developing the finest thing of its kind;" and so on through the long list. The immature thus boast of growth, bigness, the highest buildings, and what not. In any event, some longing is expressed by urban dwellers in connection with their city life which bears on the future of the city. St. Paul meant some such thing when he set himself down as "a citizen of no mean city." It is because of this psychological something that reference is made to the city as a way of life. It lingers in our historical descriptions when we speak of the "Athens of Pericles"—"Rome in its glory"— or "Italian cities in the Renaissance." Looked at from this point of view most American cities have in no sense found themselves or their objectives. Many cities known to history have expressed the best of the civilization of which they were a part. They developed a civic patriotism which we do not know. Such an attainment still lies before us. Even in our greatest city, and one of our oldest, what we have is made up of the labor of millions each bent on his own ends. It is not the product of a people working together with a program expressing the city as it ought to be or as they would have it—a structure with unity, coherence, and an emphasis on some objective.

He is bold who ventures to suggest the character and the quality of the city of the future. It is possible to predict some of the physical trends and perhaps the industrial. But what the human city will be

will depend in the last analysis upon the changes which will come in our thinking. For as a city thinks, so it will be in spite of physical and industrial forces—or perhaps better, because of its control of such forces. There are some facts which are apparent enough to suggest an approach to the problem:

1. We are gradually approaching the time of maximum population—a period of stabilized numbers. Population students tell us that by the decade 1950 to 1960 we may expect the census figures to remain relatively constant. It would seem that the day of immigration is over and the time of small families has come. There is no economic reason for an enlarging population. Furthermore, city populations are growing older.
2. Many cities which have no real physical roots are likely to lose population and perhaps die.
3. Cheap electricity and long-distance transmission, together with cheap transportation by public highway make for some form of decentralization and a suburbanization of populous centers.
4. On the other hand, a rational economic development cannot mean a general "back to the land movement." Agriculture as a business cannot absorb any more workers or proprietors. Agriculture as a way of life is attractive for the most part only to those who have a competence or an income from a non-agricultural source. In other words, we are industrializing and mechanizing agriculture and at the same time urbanizing rural life. Thus we seem to be merging and consolidating the advantages of rural and of urban life. The city goes to the country with good roads, machinery, the telephone, gas, electric light, the radio, bathrooms, and much more, and the country comes to the city with light, air, open spaces, health, and fresh markets. And transportation is the link between them. There can thus be no economic or business reason for a return to agriculture unless we are to confess that most of us are to live on an agricultural subsistence level. Such a confession is tantamount to an admission of the failure of inventive and educational progress.
5. There are enough social advantages in city life—that is, in the urban way of life—to lead us to believe that we will conserve them without question. With all of his enormous popularity and personal appeal Gandhi has made relatively little progress in turning the clock back to hand processes. The machine is here to stay and the machine is the industrial symbol of the

urban way of life. If we can substitute spaciousness for dirt and congestion, city life will retain its lure for the majority.

6. The increased leisure which is upon us, if only it becomes voluntary rather than enforced leisure, guarantees the future or urban populations. Man is a social animal and he insists on being with his fellows. Throughout history he has congregated in cities for mutual aid and satisfaction whenever he could be released from the daily business of producing food. As food production becomes a minor interest in his life he will do what he has always done—seek other satisfactions in company with his fellows.
7. The arrival of comprehensive planning, and this includes zoning, will continue to stabilize city populations and the values of urban life. Eventually we will recognize that planning is not a fad nor a plaything of so-called intellectuals, but a fundamental human and social need. Every interest, whether economic or social, is bound up in this prime necessity of our lives. Indeed, only as city planning becomes regional and national planning can we hope to avoid the chaos which continually threatens us. Those who have lived in tropical clearings know how the jungle returns to recapture and set at naught the work of man. So our urban life is threatened with extinction unless we plan to conserve the values which we create.

Some tentative conclusions suggest themselves if there be some agreement as to the statements just made. And these have some bearing on urban development during the next few years:

1. If cities are to grow rapidly as many have during the last generation they can grow for the most part only at the expense of each other. Natural growth will come only if the natural advantages of location or environment are more or less outstanding. New inventions which meet new needs will bring new industrial establishments to fortunate communities, but there seems little reason for expecting that industry will continue to concentrate further in our larger cities. The reasons for such concentration are no longer valid. This is one way of expressing the tendency which is so often called the decentralization of industry.
2. Present cities of considerable size are becoming the focal centers of an urban and semi-urban area of large proportions. What we now call a metropolitan area will take on some of the physical and social characteristics of the ancient and medieval city-state. Whether these regions will become politically unified and have

any corporate entity will depend upon the rapidity of social and economic integration, the development of planning on a large scale, and the breaking up of provincial thinking. In any event we may look forward to the time when there will be much less agricultural land in crop cultivation within such areas and much of the open land given over to forest, park, and recreational spaces.

3. Within the old corporate limits of the concentrated city there will come an irresistible movement for slum elimination. The slums will give way to well planned sections of houses and to open spaces which make life tolerable and attractive for those who still must work in the heart of the city. Trees will come back and grow where our grandfathers built cobblestone pavements. The small rectangular block will give way to superblocks of varying shapes and designs, and the area now given to streets will be cut down drastically. As electricity replaces steam power for industry and heating the "old" city, the "basin" or the "loop," will no longer need to be smokey, dirty, and unsanitary. It can become again what it once was, a desirable and close-in place to live.
4. Cities must be places in which to live as well as work. This must be the concomitant of shorter hours and the use of machines in industry. Urban life must tend to be one of considerable voluntary leisure, and city people will have adequate opportunity to join in all of those things which advance the culture and harmony of city life.
5. Fundamental for such an urban life is adequate income and social and economic security. As we have time on our hands our desire for the fuller life develops and a demand for a higher standard of living makes itself felt. Thus grows the insistence for more comforts and more things. To industry and business this raising of living standards is the bread of life. It should also carry the warning that, of supreme importance in any consideration of the city of the future is the working out of the method by which sufficient income can find its way to all. For purchasing power is the fuel of the industrial world we have set up. Modern industry cannot operate without it. It thus goes without saying that in a world of machines, cities as aggregations of human beings will disintegrate and die if there is not a steady, sure, and constant increase in purchasing power.
6. With the stabilizing of city populations and the general accept-

ance of the fact that growth in numbers cannot continue at the old rates, we will become more rational in our attitude towards land and land values. We will see that land which is not used contributes nothing to the value of urban life. We will then begin to put land in its place and find its true function. There will be common agreement that the day of land speculation is drawing to a close. Delinquent taxes on vacant lots in a hundred cities are eloquent testimony as to what is coming.

Certain other tendencies seem to follow with good reason:

1. Real estate values will fall in our least desirable sections and in undeveloped areas. This means an impetus for slum rehabilitation, for it is increasingly apparent that it is the inflation of land values that maintains the slum and retards low-cost housing developments.
2. Our present theories of real estate taxes will need reconsideration.
3. The vertical expansion in our central business districts will be slowed up.
4. Much land now held for commercial and industrial purposes will not find any such use. This may also become true of residential areas as families get smaller and the population gets older. For instance, in 1930, 23 percent of our population was 45 years of age and over. Within the present century this percentage will probably double as our population numbers become static.
5. It may follow that future building will come in the field of smaller and perhaps semi-detached houses, and doubtless in newer types of multiple dwellings.
6. There will be much less shifting of families and therefore more stability in neighborhood life as the average population age increases.
7. The demand for extending public facilities of certain types will slow down. For instance, we will need fewer *new* school buildings. On the other hand, we will find a demand for more institutions for old people and more recreational areas.
8. The demand for transportation of all kinds will increase as leisure increases. Transport will come to be of greater and greater public interest.
9. In the field of water—our field today—I think there is little question that we shall demand in accelerated fashion more and better water. As our cities run out into the country our water

utilities will tend to become metropolitan systems. The per capita use of water will increase and the demand for better pressures, clearer and more potable water, advanced fire protection, and no doubt softening, will keep our hydraulic engineers alert, alive, and indispensable for an indefinite future.

Just at this moment the city trembles in the balance. Its citizens are in large numbers unemployed, its finances are in chaos, its services and its structures are deteriorating, and both public and private hopes are sagging. We begin to realize that somewhere we missed the mark or took the wrong turn. Apparently our material prosperity of the last generation was either illusory, or it was obtained at a tragic price. The transformation of millions of workers into automatons brought its toll when machinery itself became automatic. With the disappearance of artisanship we lost certain conceptions which have always been basic in a civilization. The industrial city to date has not proved its place in the sun.

But—the machine age is here to stay. It must be whipped into condition to serve human needs. Something will have to take the place of the handicraft world which after all did create beauty and some serenity, even though it may have done little to better general living conditions. The mass of mankind has perhaps been ill served through the centuries by human institutions. Human intelligence has made it possible to bring to all of us in cities a better individual and a better community life than has ever existed on this globe. The city is not to be a menace as Jefferson thought. Whether we like it or not, the national economy of the future will be controlled from urban centers and by urban conditions. Urbanism will dominate the future. Since we cannot recapture the pre-machine age our obligation is to make the machine age safe for the future city. Planning on a large scale, with technology as a basis, furnishes our hope. We must stand fast in the presence of the machine and explore its significance.

In the last analysis, it means that we have a mass civilization to contemplate and deal with. Adjustments must be made in the light of these fundamental changes in our economies. If these do not take place "the growing sickness now threatening us will shatter our social life." Charles Beard says of the problem of urban life before us, "Even the contemplation of its possibilities is as worthy of human nature as meditation on the chances of slipping into heaven through the narrow gate of personal perfection."

We come now to the final word on what the future of the city is to be. In our dreams it is something beautiful, with a plan of growth and a contented and happy people. It is a balanced structure full of opportunities for work and play. There is enough industry to provide for the needs of all, but not so much that we cannot use our products for lack of purchasing power. The machine has become the servant and not the master of man. It is a civilization that we are creating, a harmony of the necessary and the good things of life. So let us have a comprehensive plan and a pattern to work to. Let us reconstruct our slums and rehabilitate our blighted areas. Let us organize for civic achievement as we have been doing for business and industry. Let us measure our city not by size or by numbers, but by its results in terms of human beings who stay young, who have a zest in life, who are gay and spontaneous.

These city dwellers will work, of course. They will want to, but they will also need to share in some great and common enterprise. The spirit which built the Parthenon and the great cathedrals cannot be dead. Human nature has suffered no such deterioration in spite of the routine induced by the modern machine. Just as the home has been transformed by the inventions which have simplified the old housekeeping regime, so the city itself can be transformed when we learn to use mechanical processes in building a city life. Just as women have been released from routine for great public enterprises, men will come to have public interests outside of their daily toil. This is what happened in Athens where citizens had time for public concourse. We may even recreate a public life of fetes and ceremonies when the city becomes a source of pride to all of its inhabitants. In any event, we have the materials out of which to build cities of glory and grandeur. We need only the conception and a new attitude toward our problem.

We in America have not yet scratched the surface of the possibilities of life for all—a life promised by our boundless resources. We have yet to plan the framework for a future of abundance. Let us set about this planning—comprehensive planning—with good will and courage, and let us begin now.

ECONOMIC SECURITY

By Henry M. Waite

(Director, Regional Department of Economic Security, Cincinnati, O.)

You might as well ask what is meant by Economic Security. There is the Economic Security of the individual. There is also the Economic Security of a family, of a community as well as of a country. You cannot solve the latter without first solving the problem of the individual.

This is one of the great lessons that the present economic crisis has taught. When the world begins to think in terms of people rather than things we will have made a great step towards the solution of our main economic difficulty.

This Bureau, the Regional Department of Economic Security, is making the approach to the individual through unemployment. We are setting up an Employment Bureau as the nucleus for study and research. In this manner we can serve the employer and the employee, through coöperation, by more nearly putting the right man in the right place. You appreciate that it is a large task as well as an important one. We are trying to set up the ideal as our objective. In this manner hoping to be able to set up through research on the employment records, the best approach to this important problem. The Employment Center is a laboratory. To be a laboratory it must be a practical set up and used by the employer and employee. It must give service to both or it will not be a laboratory.

The following are some of the objectives:

1. Supply and demand of labor.

2. To indicate the industries that will first need additional help, such as: shoes, clothing, etc.

3. A research to indicate what can be done to fill the low gaps of employment in various industries between peaks, for stabilization in the same line.

4. A research of juniors, back into school records to evaluate vocational guidance and training in schools. Records indicate too many

youths in "white collar" and not in trades. A research of school records to indicate any possibilities, proper selection and training of youths for trades to fill the prospective earliest demand of industry.

5. What are the unemployables in the community?

6. The study on rehabilitation should extend to retraining of those who have been idle so long that they have lost their previous skill, as well as the advances in industry in the method of new machinery.

7. With the flattening of the population curve and the increase in number of higher age brackets and decrease of lower age brackets will necessitate a research in industry as to what age efficiency begins to decrease.

8. Unemployment registration—to see if unemployment is due to economic changes and economic causes or due to personal deficiency and to skill.

9. Residence changes—real estate values going down.

A great deal of data on unemployment as well as experience was accumulated by the relief and other agencies during the expenditure of $3,300,000,000 made available in the Relief Bill of 1933 and a great many of the objectives mentioned above are outcomes of this experience.

At the time of writing this paper the whole country is again waiting with great expectancy as to how the $4,800,000,000 for work will be handled. We are contemplating great demands on this Bureau in the employment of people now on relief.

We are all familiar with the difficulties of the expenditure of the money made available by the Relief Bill of 1933. When one branch of government has to make contracts with other branches of government for the expenditure of money through contracts, the complications and delays are natural. We are realizing, at least I hope we are realizing, the fact that old established institutions are incapable of executing new ideas.

However, public works, with the money of 1933, has been a backlog of recovery. It is unfortunate that more money was not made available for similar expenditures in 1934. The ball had been started and should have been kept rolling. With the money available this year we will help take up a good deal of the slack lost. The great handicap is, however, that today there are few of the cities, most needing work relief, that have credit for loans. This will call for a more liberal policy if we are to take people off of relief and put them on real work jobs.

There are many complications in the new bill which are going to make its execution by the administration most difficult; such as, limitations to salaries, etc. This one item, I fear, will be a tremendous handicap. It will necessitate a greater usage of existing governmental departments in helping solve this difficult problem.

Naturally, there has been a great deal of criticism of PWA but, by and large, it was a tremendous undertaking and fairly intelligently handled. I find that most of the critics of PWA cannot see the woods for the trees. When you realize that practically every county in the United States received some work benefit from the original money of 1933. Take the items that you are particularly interested in—Sewer and water projects:

	NUMBER OF PROJECTS	ALLOTMENTS	ESTIMATED COST	EMPLOYES AT THIS DATE	MAN-HOURS USED TO DATE
Non-Federal Projects (through Jan. 1935):					
East of the Mississippi..	879	$162,384,852	$193,313,744	20,221	24,324,143
West of the Mississippi..	711	77,787,069	110,300,938	9,730	8,408,889
Federal Projects (through Nov. 1934):					
East of the Mississippi..	54	2,526,471		732	688,024
West of the Mississippi..	103	1,781,440		483	665,490

This represents a total allotment for both Federal and non-Federal projects of $244,479,832 on 2,347 projects.

It is amazing to find the number of projects of this character that are completed and are under construction. The largest project is the Sanitary District of Chicago, Illinois, with an estimated cost of over $29,000,000.

The figures on CWA work are still incomplete, but it is estimated that 13,000 Sewer and Drainage projects were carried on under the CWA, at a total cost of $90,000,000. Of this amount, 79.8 percent was expended for salaries; 3.7 percent for teams, trucks and equipment and 16.5 percent for materials and other costs.

For the week ending January 17, 4.7 percent of the projects active under FERA were Sewer and Sanitation projects, either new construction or repair. These projects employed 151,892 men during that week.

In handling the thousands of applicants we must be able by short cuts and simple methods to get all the necessary facts for research. These methods must be practical and must not discourage the applicants. The record of each applicant must be such that we can match the requirements and classifications of industry and yet, at the same time have a record on which we can base research for our objectives.

We started out with the idea that interviewing could be done by trained interviewers. We soon found that this was not the entire answer to the problem. It reflected too much the personality of the interviewer. It also requires, however, a standardized background through certain tests that would give us a more uniform picture of the applicant that it was possible to obtain alone from the personal interview which is also needed.

These records have to be carefully arranged so it is possible to use Hollerith cards and get the grouping necessary to fill the classification of the employer as well as such classification as will be needed by research to obtain our objectives.

At the same time we must always bear in mind that when our research is completed, we must leave a workable, simple and economic system of handling employment so that it can be taken over and operated economically and efficiently as a regular State-City Employment Center.

The entire country today is awakened to the problem of unemployment. This awakening is followed by all kinds of organizations, with the best intent in the world, trying to work out the answer or at least a part of it. It is one of our tasks, and no easy one, to study all of these earnest endeavors and try and correlate and coördinate these efforts to a common acceptable objective. When we are through we will be able to show clearly the supply of and demand for labor. We will be able to indicate which industries will need additional help first. These indications will automatically be shown through the Hollerith system.

It then becomes the problem of vocational education and guidance of industry to work as quickly as possible and anticipate these shortages by training or retraining. This will stop bringing in outside labor as long as good material can be trained locally.

For many years, this country will have more unemployed than we have had in the past. This will mean that each community becomes an economic entity. It must be able to meet the industrial requirements and not force industry to go outside of the community and

bring in additional help as long as they can be supplied by intelligent forecast and training locally.

The Regional Department of Economic Security, by studying the individual, can greatly assist in the solution of the Economic Security of the community. When you allow your mind to travel in the direction of retraining of those employees whose return to their trade is slow, you realize we are getting into a most difficult social problem.

We hope we will be able to throw some light on the great problem of rehabilitation. We know very little about grouping job characteristics. What aptitudes has a machinist, a carpenter, a clothing worker, a shoeworker, that would lead toward training for another job in the shortest possible time and obtain the best results?

The Federal Government is doing some very interesting work on this subject. With our organization in Cincinnati we will be able to check some of these studies in their practical application. How many workers want more than one job? Would a worker prefer to go on unemployment insurance than be trained for a new job? We realize that there are a great many workers who would prefer and are satisfied with feeding an automatic machine. Their work becomes so automatic that they can let their brains dream on anything they desire to dream about and pay little attention to the detail of their work. Can these people be trained in other fields?

We have so many seasonal occupations with high peaks. The ready-to-wear clothing industry has two high peaks a year. The made-to-order clothing industry is more even throughout the year. Can these two industries be combined or is it necessary to train seasonal ready-to-wear workers into other trades? What are the characteristics of a pocket worker that would fit her for some other task? Does she want to be fitted for another task?

Has the United States a social consciousness, both employee and employer, to see this picture and work in a common effort to aid in protecting the economic security of a community. Here is a wide open field for public education. Will the individual worker be happier with two strings to his bow than one, or would he rather have one string and be on unemployment insurance.

We all realize that we are going to have shorter hours and correspondingly higher pay. We also know that our population curve has flattened out with the cutting off of immigration. Already our population trends show greater percentage in the brackets from 35 to 50 years and a cutting down of the percentages between 21 and 35 years.

Here old age pensions would fit in or the development of services for the population in the higher age brackets.

Shorter hours brings up the necessity of recreation for more people —recreation for the old as well as the young.

The Regional Department of Economic Security in Cincinnati hopes from its records and research to indicate the trends of some of these important economic and social problems but above all it indicates that with changes in our economic situation we must know more of the social values of life.

RECONDITIONING WATER SUPPLY LINES WITH BITUMINOUS ENAMEL

By Linden Stuart

(President, Wailes Dove-Hermiston Corporation, New York, N. Y.)

The need for reconditioning water supply lines is today, more than ever, occupying the attention of water works engineers all over the world. A great number of water supply lines are in urgent need of cleaning and recoating, not only in order to restore their carrying capacity, but also to extend the useful life of such lines.

NEED OF RECONDITIONING

Years can be spent on securing data regarding the types of water which cause corrosion and tuberculation, the measuring of carrying capacity, and the performing of flow tests. Valuable information is secured in this way for future use. Recent studies have shown, however, that the carrying capacity of many existing systems is considerably less than was predicted when the lines were laid. A surprising loss in carrying capacity has been proven. Therefore, the important problem of immediate moment is "What can be done about existing systems now?"

The practical course to follow, by any water works engineer faced with diminishing carrying capacity, resolves itself, like any other engineering problem, into a matter of adopting the most economical of the three courses that are open: (1) build a new conduit; (2) clean the mains and introduce chemical treatment, or; (3) clean the mains and apply a protective coating in order to maintain the restored carrying capacity and prevent further structural deterioration of the pipe.

This paper is concerned mainly with the third solution, namely the reconditioning of steel or iron water supply lines with a lining, and more particularly a bituminous lining. However, it might not be inappropriate to say a word here regarding the second method, namely, the introduction of chemicals.

The introduction of chemicals to a water system is not new and has been used for years for various purposes. The primary purpose has been the destruction of harmful organisms.

A consideration of each individual problem should include the estimating of cost and the determination of advantages and disadvantages of each of the alternate methods as applied to the particular case. Corrective treatment is a problem requiring careful consideration as to the best chemical for the particular water and the determination of just how far to go without overdoing it and including provisions for reasonably continuous control to keep the treated water within the proper limits.

The need and the potential demand for reconditioning of distribution pipe is well known and recognized. There are several methods now in use for this purpose, but this paper will be confined to the reconditioning of supply lines of diameters in which it is possible for men to enter and work.

NEED FOR PIPE PROTECTION

The vast majority of steel, cast iron, and wrought iron water supply lines laid 20 to 40 years ago, received no protection against corrosion and tuberculation other than a light foundry or mill dip. In many cases, additional metal thickness was adopted to resist possible pitting and corrosion. Many engineers then considered protection a sheer waste of time and money. There was, without doubt, some justification for this sentiment at that time. Many of the methods of protection offered then were not backed by any satisfactory record of performance and have been proven by subsequent experience to have been inefficient and very inadequate. Furthermore, facts and figures concerning the enormous toll in reduced carrying capacity caused by tuberculation and corrosion were not then available to engineers, and no proof of the value of the restoration or maintenance of carrying capacity or life of the pipe could be presented, as is the case today.

This feeling regarding pipe protection was not peculiar to water works engineers alone, but was shared by many oil and gas engineers. It was not until the sudden expansion of the gas and oil transmission lines that economics forced the consideration of the lessened cost and the better protection afforded by the improved coating materials and methods now available. These were not only cheaper than extra thickness of metal but better adapted to resist pitting and corrosion.

The engineer of today, however, has at his command very complete and convincing evidence of the havoc wrought by corrosion and tuberculation, and actual proof of the value of restoration and maintenance of flow effected by the use of proven protective materials.

TIME TO RECONDITION

The time when a water supply line will demand reconditioning is governed by many factors, such as the corrosive or tuberculating character of the water, the adequacy of the original protection, if any, the length of time that the pipe has been in service, and its existing structural condition, as well as the possible requirements for additional capacity, particularly if a community is growing. Reconditioning in general becomes economically desirable when tuberculation has reached the point where it reduces the carrying capacity of the line or where corrosion threatens the structural life of the pipe itself. If the supply line is still ample for many years to come, then the immediate need for reconditioning can be postponed provided there is no danger of structural weakening of the pipe line material, which may cause failure, if neglected.

As the demand for greater carrying capacity nears the actual capacity of the line, then it is a simple matter of economics to determine whether it would be cheaper to clean and re-line the existing conduit (assuming that the restored capacity would be sufficient) or to build a new conduit.

In a force main, special conditions enter in the matter of pumping costs. Application of a smooth lining in such cases will naturally pay a much more rapid return on the investment than in gravity lines where no power is required. Sometimes a return on the investment in the lining of 33 to 50 percent results.

THE OLD TIME COATINGS

Many of the older steel lines in this country were originally coated with asphaltic dip coatings of one type or another. An examination of many of these lines has shown severe tuberculation and corrosion. The carrying capacity has frequently been reduced by tuberculation to 65 percent or less of its original amount. In many cases the old dip has completely disappeared from most of the pipe. In some sections the old asphalt coating is still found in place but tuberculation seems to be "growing" right through the old coating. In others it still seems to have "life" but has not prevented corrosion or tuberculation. Laboratory analyses of old asphalt dipped coating, from lines that have been in service from 8 to 23 years, show that these coatings have absorbed from about 30 to 60 percent moisture. Frequently, corrosion has started at some individual point, but, instead of being confined, has traveled extensively under the coating

without any evidence of the corrosion appearing on the surface of the coating.

The tar dips have been more resistant to water absorption and chemical action of soil waters, but have been entirely too thin to afford permanent protection. It has also been found that such coatings were not homogeneous. Frequently the tar dip was of poor quality. Many pipe had evidently been too hot when dipped. This had burned the coating to such an extent that any protective value it may have possessed had been destroyed. Frequently this condition had occurred on only one end or one side of a pipe, showing that the pipe had not been evenly heated before dipping. This was a frequent fault in dipping practice. Pinholes, air or gas bubbles, pieces of coke and similar defects of the thin coating had permitted corrosion or tuberculation.

THE MODERN COATING

Many years of observation and study of the better grades of bituminous protective coatings on old pipe lines, not only in water service but for oil and gas use, have definitely proven the superiority of a properly compounded coal tar pitch base coating over an asphaltic coating and the necessity of a substantial thickness of approximately $\frac{1}{16}$-inch. Laboratory analyses of one such coal tar coating on the interior of several large diameter water lines, where the coating was subjected to water under pressure day and night for periods as long as 18 years, showed a moisture absorption of only one-tenth to one-quarter of one percent. Contrasting this performance against the 30 to 60 percent water absorption of similarly exposed asphalt coatings, mentioned above, emphatically indicates one superiority of the coal tar material. Another advantage of the coal tar enamel is its chemical inertness. A good coal tar enamel will not disintegrate with age. It will not be chemically affected in the slightest by water or the usual acids and alkalis of ground waters or even by sewage, as shown by its use as a lining for metal sewer pipes. If there is any holiday or mechanical break in the coating, which was missed during final inspection, the water will come in contact with the pipe metal and corrosion or tuberculation may develop. It will be confined, however, to this small area, and will not travel under the coating, as occurs with asphalt materials.

No laboratory or accelerated tests have yet been developed to demonstrate conclusively the worth of any pipe coating material.

All available tests are of value only in eliminating obviously worthless materials. There is then no means of definitely determining the value of the remaining materials in a test. One important reason for this situation is that there is now no method of predicting what, if any, change may later occur in the physical and chemical properties of a coating due to age. In the final analysis, therefore, the criterion in the selection of a good coating material must be based on long-time performance records on actual existing pipe lines. The use of new or untried coating materials for such important work as the inside of a water line can only be considered, in the light of past experience, as a hazardous experiment.

RECONDITIONING OF PIPE IN A STORAGE YARD

The reconditioning of old pipe, which has been dug up for re-location, and is available in single lengths, does not present any serious difficulty. Reconditioning work can be performed satisfactorily by various methods on pipe down to 4 inches in diameter. This offers an opportunity to reclaim pipe in districts where the demand has grown greater than the carrying capacity and, after reconditioning, to re-lay in other locations where the diameter will be adequate to carry the required supply for that district, thus economizing on the purchase of the pipe.

The usual method of doing this work is to line this pipe in a storage yard with bituminous enamel. A spinning machine, usually supplied by the coating manufacturer, is used for rotating the pipe and hot bituminous enamel introduced into the pipe. The spinning distributes the hot enamel evenly over the entire inside surface and results in a thick, very smooth lining with a high coefficient. This cleaning and lining is now being done by several municipalities, not only on old pipe to be reclaimed but also on new pipe. It is working out very successfully.

Where bituminous lining is desired on larger quantities of new cast iron pipe, the pipe can be purchased from the foundries with the lining already installed.

RECONDITIONING OF PIPE IN PLACE

For existing pipe now in place, which is large enough for workmen to enter, the usual method is to apply a hot bituminous coal tar enamel to the interior by hand brushing, after proper cleaning, drying and priming of the pipe surface. This is, in the long run, the most

economical protection for such pipe lines, as it gives the maximum amount of protection for the least amount of expenditure. At the present time, the smallest pipe possible to coat in this way is about 30 inches in diameter.

The pipe must be clean and dry before the bituminous lining is applied. All water, rust, old coating and tubercles must be removed and the pit holes cleaned out. The pipe must then be dried, and a priming coat of bituminous solution of the consistency of ordinary paint is applied by hand brushing. After a suitable drying interval, this is then followed by a hot hand application of bituminous enamel to a thickness of about $\frac{1}{16}$-inch. The principal considerations to be thought out are the sequence of the operations, so that the whole work proceeds in a uniform manner. There must be proper ventilation for the men, and to blow away the dust caused by the cleaning tools and the fumes from the hot enamel, and the correct volume and dryness of air must be introduced through blowers properly to dry the pipe. Other considerations are the staggering of various operations so that the entrance and egress through a few manholes, usually a thousand or more feet apart, can be properly worked out to avoid the necessity of workmen passing over freshly primed pipe. The proper arrangement and distribution of lights, blowers, air tools, and other paraphernalia and equipment is important, and is based on previous experience.

To take up these operations in detail, any method of cleaning which gets down to the bare metal and cleans out the pits, would be satisfactory. In New York City, sandblasting was tried, but the weight of sand and the handling of such vast quantities in and out of small manholes, together with the fact that the sand had to be screened and dried before it could be used over again, made it very troublesome and expensive. Fine particles of sand cut and broke the electric light bulbs and necessitated the use of masks and goggles by the men. It was found that scraping by hand with steel scrapers, followed by mechanical wire brushing, cleaned out the pits satisfactorily and made an excellent surface for later enameling, at a much lower cost than sandblasting. The preliminary cleaning by means of pneumatic chisels was tried, but later dropped in favor of hand labor with steel scrapers for removing the original tuberculation. Not only was this hand labor cheaper, but actually provided more work for a greater number of men which is an important item at the present time. The electrically driven tools had a tendency to heat

up and slow down if too much pressure were applied. In this respect, the air-driven tools were superior but necessitated the use of compressors.

Sometimes it is best to do the rough hand cleaning while the pipe is still damp. This keeps down dust and makes it easier on the men and the additional volume of muck to be removed is not great. The final mechanical wire brushing should be done when the pipe is fairly dry. This, of course, is a dusty job. It is sometimes necessary for the men to use masks during this wire brushing operation because of the dust.

The water main cleaning companies are in a position to coöperate on the preliminary cleaning.

In drying and ventilating of pipe, air blowers are used of sufficient quantity to carry off the moisture and the size of these blowers depends upon the diameter of the pipe and the distance between manholes. On some municipal work, small enclosed portable houses have been built over the manholes to act as an air lock so that the manhole opening is not obstructed by the blower pipe. The blower then blows or exhausts into the house as an air chamber rather than directly into the pipe, leaving the manhole opening free for entrance and egress of men and materials. It is, of course, necessary to properly space the bulkheads, generally of canvas, that are used in the pipe, so as not to blow dust over the finished work and to circulate the air to the best advantage. The only difficulty experienced with ventilation is in hot weather when the moisture in the warm air from outside condenses on the cool interior surfaces of the pipe. As this happens only in hot weather, the best time to recondition pipe in place is in the Fall and Spring, or during the Winter months. The use of proper air conditioning apparatus will, of course, permit work at all times, but might add to the cost throughout the long hot weather in mid-summer.

During the present unemployment situation, this reconditioning work is very desirable because of the uniform sheltered conditions inside the pipe line, enabling many men to work at a time when outdoor weather conditions would preclude efficient employment.

The priming of pipe should follow as closely as possible the cleaning and drying because if condensate forms on the pipe, rust takes place very rapidly.

The hot enamel follows the priming as soon as the primer has dried, usually after a minimum time of 24 hours. It is applied by means of

Tampico Daubers in strokes parallel to the longitudinal axis of the pipe. These strokes are lapped over preceding strokes at the sides and ends. The brush marks eventually become smooth and disappear due to the water pressure after the pipe is put back in service.

Much experience has been gained in connection with this reconditioning work on various existing pipe lines, such as the 48-inch diameter for the City of Newark, N. J., the 72-inch diameter for the City of New York, and the work now being done on the 72-inch diameter for the City of Jersey City, N. J.

Most of these old pipe lines are of riveted pipe made up in 6 or 7 foot sections and special care and inspection is necessary at the joints to see that the space between the rivet heads is thoroughly cleaned and properly coated. Specially designed scrapers are used for this purpose and wire brushes, of cup-like shape that fit over the rivet head, are used in cleaning around these rivets.

The hot coal tar enamel is passed in through the manholes in buckets. In bulk it does not cool so rapidly as to congeal before it is applied. After a section of 4,000 to 5,000 feet is completed, it is customary to go through and inspect and mark up any missed spots or holidays. A touch-up man then makes sure that these locations are properly protected.

COST OF RECONDITIONING OF PIPE IN PLACE

The cost of this reconditioning work is greatly dependent upon following a fixed schedule and in so synchronizing the various items as scraping, removing of old material, wire-brushing, cleaning, priming, enameling, and ventilating, that the work will progress uniformly at a fixed number of lineal feet per day. To accomplish this, it is necessary to organize the job, thoroughly, to arrive at the proper number of men of each group in their proper numerical relationship so that the scraping, for example, will not get too far ahead of the wire-brushing, or the wire-brushing too far ahead of the priming, etc. This organization of labor is, of course, a matter of experience, knowing the capabilities of the men and the area of surface which they may be expected to properly cover on the particular operation on which they may be engaged. Some of the items of cost to be considered would be as follows: (1) Digging up and uncovering of manholes. (2) Maintaining traffic where the manholes are on the main highway. (3) Transportation of men and materials. (4) Insurance. (5) Labor. (6) Superintendence. (7) Overhead. (8) Rental of equip-

ment. (9) Interest and depreciation on equipment. (10) Materials. (11) Supplies. (12) Ventilation (blowers). (13) Lighting (generators). (14) Trucking. (15) Miscellaneous.

In general, the cost of reconditioning large diameter pipe lines should run in the neighborhood of 20 to 25 percent of the cost of a new line, installed, of the same size. No definite figure can be arrived at without knowing the specific conditions of each job, such as the size, length and location and present condition of the conduit, the labor and equipment available, time of year in which the work is to be done, how long the line can be put out of service, and similar items.

EXTENDING USEFUL LIFE OF OLD LINES

After reconditioning, the carrying capacity of the pipe line has, of course, been restored. This is important, but more important is the fact that this restored carrying capacity can be maintained thereafter for many years to come by the use of a suitable lining applied inside the pipe. This conclusion is based on the fact that several inspections, within recent years, of coated pipe lines carrying tuberculating water, have disclosed that the pipe was free of tuberculation or corrosion and no deterioration of the coal tar enamel had occurred. The lines had been in service for periods ranging from 8 to 18 years. The coating had been handbrushed and was from $\frac{1}{32}$-to $\frac{1}{16}$-inch thick. It seems obvious therefore to expect even better performance today in view of the great improvements that have been made recently in coating materials and the technique of application.

Quite a few pipe line systems in this country, particularly steel, are now as old or even older than the useful life assigned to them when they were originally laid. Many of them are tuberculated to an extent that the carrying capacity is 65 percent or less of the original value. As there is a pit under each tubercle and corrosion has also taken place, both inside and outside, there has been some structural deterioration. Examinations have clearly shown, however, that they have not been weakened seriously. This new method of cleaning and recoating therefore makes it possible not only to restore the carrying capacity of these lines and maintain it for many years, but also to prevent further structural deterioration. The useful life of such lines is consequently extended far beyond the current conception of the useful life of water supply lines. When it is realized that this can be done for only 20 to 25 percent of the cost of a new conduit of similar size, the economics of this method of combating a diminishing water supply is self evident.

SPECIFICATIONS

If a municipality is writing specifications for contracting all the cleaning and coating of an existing water line, it is usual to include a maintenance bond running from 2 to 5 years, for this work is of a very special sort and not every contractor is capable of performing it satisfactorily. Contractors are also usually required to submit qualifications containing adequate proof that they are equipped to perform in a satisfactory manner the work covered by the contract documents within the time specified. This record shall show, among other things, that the bidder has a competent organization which has done work similar in the amount, value, cost, character and proportions; that he has available for immediate use on the work, the necessary plant and equipment; the name of the manufacturer of the bituminous coating, trade name of the coating materials, location of the plants where such material is to be made; the name of all the officers of the bidder corporation; the name of the executive who will give personal attention to the work whenever so desired by the municipality.

ACKNOWLEDGMENTS

In conclusion, the writer wishes to pay tribute to Mr. Andrew B. Mauzy, Water Conservator, City of Jersey City, N. J., where this work has been carried on for the past two years and to Messrs. Bank, Garratt, Simpson and Anderson, of the Newark, N. J. Water Department, where some 42-and 48-inch pipe has been reconditioned in this manner, to Commissioner Eastman, Messrs. Brush, Goodman, Hauck and Drew, of the Department of Water Supply, Gas & Electricity, New York City, to Mr. Leonard Wood, of the Board of Water Supply, New York City, and also to Mr. George E. Boyd, member of the organization with which the writer is associated, who, by their active participation, cooperation and interest, have made possible the development of this method of reconditioning pipe in place, with all that it offers to the water works in extending the useful life and in maintaining full capacity of water lines, and in maintaining a higher valuation for rate making purposes.

CEMENT LINING OF LARGE DIAMETER MAINS IN PLACE BY A CENTRIFUGAL MACHINE

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During the past three or four years, particular interest has developed in the inter-related questions of capacity loss of pipe-lines with age, and various remedial measures of dealing with the problem of capacity loss.

CAPACITY LOSS IN PIPE LINES

Among important contributory causes focusing attention upon these questions, are the following:—

1—The ever-increasing number of pipe lines approaching a condition of serious inadequacy because of loss of hydraulic capacity after a number of years of normal operation.

2—The increased aggressiveness of supplies following some types of water treatment, with a consequent accelerated rate of capacity loss in mains carrying these waters.

3—The opposing trends represented by a constantly rising rate of consumption and draft, in normal times, as compared with the progressive downward trend of available capacity.

4—The limited appropriations available in recent years for duplication of works, and the resulting concentration on ways and means of rehabilitating existing old pipe-lines.

In the design and financing of pipe-lines, periods of 30 years are frequently assumed as a base. Early data indicated that during a period of this duration, under average conditions, a capacity loss of from 30 to 35 percent might develop. Recent information indicates that the loss of capacity during a 30-year period may be from 30 to 50 percent for large supply mains, and from 50 to 85 percent on small distribution mains. When capacity reduction in 30 years assumes such proportions, remedial measures are frequently necessary in periods of much shorter duration.

The history of the Coolgardie pipe-line may be referred to as an instance of the extreme degree to which capacity reduction may develop in a relatively short period of time, and as an example of the accompanying substantial financial loss.

This particular pipe-line, of 30-inch steel pipe of the lock-bar type, with sleeve joints, is 350 miles in length. A capacity loss of 42 percent was developed after 10 years' service, and as the line cost approximately $9,000,000, the equivalent financial loss was accordingly $3,780,000 or $387,000 per year for 10 years.

When conditions in any way approaching the foregoing circumstances are found to exist, any possible method of curbing such loss is obviously worthy of consideration.

ALTERNATE METHODS OF PIPE-LINE RE-CONDITIONING

Interest in the problems of capacity loss, and in methods of reduction and prevention thereof, has led to the development of several methods of reconditioning old pipe-lines. The purpose of such reconditioning is two-fold. First, to bring the lines back to a point reasonably approaching the original capacity; and, second, to preserve the pipe and to provide a comparatively permanent lining to prevent reoccurrence of such loss.

By this procedure a reserve capacity may often be obtained at comparatively nominal cost. If the reconditioning method provides a relatively permanent lining, the line can be continued in service for a substantial period, thereby making possible the installation at a later date, of much smaller diameter auxiliary lines than would otherwise be required.

The question of lining new pipe before installation has been frequently discussed, and, accordingly, this paper deals solely with the subject of lining pipe in place.

Four methods of re-conditioning pipe-lines in place, subsequent to cleaning, which have recently appeared in the waterworks field, are the following:—

A—Cement lining of small mains by the "Tate" Process.

B—Electrically placed bitumen lining by the "Eric" Process.

C—Hot bitumastic enamel hand brushed lining of large diameter mains.

D—Cement lining of large diameter mains by a centrifugal machine.

The first two methods have been recently adopted in England, and have involved mains of relatively small diameter. It is reported

that the "Tate" Process for cement lining in place, has been used on mains up to 5-inch in diameter, with satisfactory experimental results on mains up to 10-inch in diameter. It is also reported that the "Eric" Process of electric-bitumen lining in place has been used in the field on mains up to 10-inch in diameter, accompanied by experimental work which has included 16-inch mains. It is also reported that this type of lining is expected to afford full protection for a period of only 5 years.

The third method, involving the hand-brushed application of hot bitumastic enamel on mains in place, is limited to sizes which permit entry for the workmen, and pipe of 30-inch diameter is reported to be the minimum size which can be lined by this method.

The last method, involving the application of cement lining in place by centrifugal machines, is, with present equipment, limited to pipe 48-inch or larger in diameter.

Plans are under way for the design of equipment with particular provision for compactness so that this limit can be extended at least to include 36-inch diameter.

All four methods require the cleaning of the mains before application of the lining, the actual method adopted for cleaning depending upon the diameter, local conditions, and the type of lining to be adopted.

Two methods of reconditioning are described in other papers on this program, and, accordingly, this paper will be confined strictly to a discussion of the cement lining of pipe in place by a centrifugal machine.

CEMENT LINING BY CENTRIFUGAL MACHINE

The centrifugal method of applying cement lining in pipe line involves the following procedure and equipment:—

1—Cleaning.

2—Preparation and mixing of the mortar of proper proportions and consistency on the ground surface.

3—Equipment for conveying the mortar within and along the pipe line from access manholes to the traveling centrifugal machine.

4—Traveling mortar storage at the centrifugal machine to provide uninterrupted operation.

5—A centrifugal machine which travels along the pipe and distributes the mortar entirely by centrifugal force upon the pipe wall.

6—The trowelling or floating of the surface of the lining after it is deposited, by slowly revolving trowels which follow the dispensing head.

7—Curing.

Equipment

The equipment used consists of a portable power plant and mixer located on the ground level, and the following units operating in the pipe line.

A—A motor-driven delivery dump truck operating between the access manhole and the actual placing equipment.

B—A traveling hopper-type storage truck operating directly behind the centrifugal machine and equipped with an inclined screw feed conveyor.

C—The centrifugal machine proper.

All units are independently motor-driven with cable reels carried to the access manhole, where power for all units is derived from a portable gasoline-driven motor generator set. The combined horse power of all units is approximately *5 h.p.*

Description of method

The pipe line to be reconditioned is first de-watered and cleaned. While the removal of tubercles is highly desirable prior to all methods of relining, requirements preceding the lining by the centrifugal machine are not as exacting as in the case of other methods, particularly with regard to maintaining a dry surface on the pipe interior.

After the line has been cleaned, the mixing equipment and the central power plant are then brought to the access manhole and the units operating within the pipeline are assembled.

Mortar of carefully selected proportions is machine-mixed with particular control to obtain optimum consistency. Both cement and sand are mechanically sieved before mixing.

The mortar, after mixing, is chuted into a delivery dump-truck operating in the pipe-line. This dump truck is equipped with a motor for independent traction, with steering facilities on both front and rear wheels, and has a small hand operated hydraulic hoist for dumping. The body capacity is 7.0 cubic feet and accordingly each load is equivalent to a $\frac{1}{4}$-inch lining on a section of 48-inch pipe 26 feet in length.

The dump truck requires one operator who receives the mortar at the access manhole, and delivers and dumps it into the feeder storage truck.

The feeder storage truck operates directly behind the main centrifugal unit. The travel speed of this truck is synchronized with the travel of the centrifugal machine by means of a contact rod connected with a brush shifting device on the traction motor. Accordingly, the sole duty of the operator of the feeder storage truck is to dump the load delivered by the dump truck.

The storage truck is provided with an independent variable speed motor for traction, together with a slow speed shaft which drives an inclined screw conveyor feeding mortar to the centrifugal machine. The hopper on this truck is of the same capacity as the dump truck and accordingly 26 feet of 48-inch pipe can be lined without refilling. This storage provides a period of approximately 7 minutes for the delivery dump truck to make a round trip to the access manhole.

The third unit operating in the pipe is the centrifugal machine, which is equipped with two motors. The first motor, for traction, has a Reeves variable speed transmission. The second motor is constant speed and drives the short screw feed conveyor, the mortar dispensing head, and the slowly revolving trowels.

Inasmuch as the mortar dispensing head is driven at a constant speed, the control of travel speed generally from one to four feet per minute, is accordingly used to obtain the desired thickness of lining.

A small hopper, having a capacity of one cubic foot, is mounted on the centrifugal unit and receives mortar from the feeder storage truck previously described. A short slow speed screw operating in this hopper propels the mortar at a constant rate from this small hopper directly to the center of the dispensing head.

The actual dispensing head, revolving at a speed of 1,000 r.p.m., depends entirely upon centrifugal force for placing the mortar. Accordingly, no compressed air is required, and difficulties frequently encountered, due to entrainment of air, are thus avoided.

The dispensing head consists of a series of slotted ports, spaced around the circumference of a circle 6 inches in diameter. Radially spaced high speed vanes rotate outside of these fixed ports and throw the mortar with great force against the pipe wall.

The high speed shaft driving the head is hollow, and on the interior is a slow speed shaft operating at only 3 r.p.m., upon which are mounted four steel mortar trowels. These trowels follow directly

behind the dispensing head, two of them operating clockwise, and two counter-clockwise. The trowels are provided with swivel joints, spring tension, and contact adjustment, so as to smooth and float-finish the lining after placing.

Range of applicability of method

The method herein described, and the equipment used, is extremely flexible in one important respect, namely, in providing a means of placing a lining of variable thickness. The travel speed of the centrifugal machine can be so slowed down that thicknesses as great as may be desired can be developed, and by faster travel, thicknesses down to any practical minimum can be readily placed.

Flexibility is important, as the thickness of the lining required may vary considerably, depending upon whether simply protection or whether protection, plus structural reinforcement is required.

In reconditioning some of the older pipe lines, sections may be encountered where the original pipe, except for tuberculation, is entirely adequate for a considerable period of service. On the other hand, cleaning may reveal sections particularly affected by electrolysis or corrosion, where structural reinforcement would be highly desirable. In such instances, increase of lining thickness can be secured by merely decreasing the speed of the machine.

This method of lining has been applied to both cast iron and steel pipe, including standard riveted, lock-bar, and welded types.

SCOPE OF WORK DONE TO DATE

Several test sections have been lined with thicknesses of $\frac{1}{4}$, $\frac{5}{16}$ and $\frac{3}{8}$ inch. One special section was lined to a thickness of $1\frac{1}{4}$ inch. A portion of this section was first provided with a heavy mesh reinforcement welded into place prior to lining, and the balance of the section had no reinforcement. It was found that the mesh was not essential to obtaining a satisfactory lining of this thickness. Such reinforcement, however, may be desirable where substantial increase in strength of the pipe is required.

DESCRIPTION OF LINING OF SECTION OF THE 72-INCH JERSEY CITY SUPPLY LINE

In November, 1933, a section 106 feet in length of the 72-inch full riveted steel supply line from the Boonton Reservoir to Jersey City, was lined with this equipment.

Several improvements in the method have been adopted since this original performance, particularly in relation to the design and speed increase of the dispensing head, to a study of optimum mix and consistency, to revised trowel design, and in reference to curing methods.

This original section is reported to have been subjected to relatively rapid drying, no curing being attempted until 44 hours after placing. At the expiration of this period the "Hunt" Process solution was sprayed on the surface. Subsequent to the application of this solution, the line remained dry for seven weeks, and both hair cracks and contraction cracks developed. The water was then turned on and upon a second inspection of the line after 10 months' service, it was found that these cracks had sealed, with only a few remaining visible.

TABLE 1

Results of tests of lining quality

SAMPLE NUMBER	TYPE OF CEMENT LINING	SPECIFIC GRAVITY	ABSORPTION	WEIGHT, POUNDS PER CUBIC FOOT
			percent	
1	Centrifugally spun by usual method	2.18	6.43	136
2	Mortar 1 part cement to 2 parts sand placed by centrifugal machine	2.14	8.65	134
3	Same as no. 2 except mortar proportions 1:1	2.26	5.06	141

In April, 1935, 17 months after the lining was placed, the line was again de-watered and inspection showed that the lining was in excellent condition. A few cracks of limited extent were still discernable on the surface, but when the curing solution was scraped off, few cracks were visible. Several pieces of lining, 3 or 4 square inches in area, were chipped off adjacent to these cracks and it was found the lining adhered to the pipe wall; and in every instance, a very considerable amount of pounding and chiseling was necessary to break away these pieces of lining.

The lining thus far placed by the Centrifugal machine has been found to be reasonably smooth, and although no tests have been conducted to determine the coefficient, it is believed that values of Williams-Hazen "C," ranging from 125 to 135, can be conservatively anticipated.

TESTS OF LINING PLACED BY THE CENTRIFUGAL MACHINE

A short section of 72-inch diameter welded steel pipe, $\frac{5}{16}$ inch in thickness, with a lining also $\frac{5}{16}$ inch thick, was subjected to a deflection test. This particular lining had been placed approximately 18 months previous to the test, and consisted of mortar of one part cement to two parts of sand with the "Hunt" Process solution utilized for curing. This pipe had been in the shop since the lining was placed, and had accordingly never been wet.

When recently loaded a deflection of 13 inches was created, and the pipe was carefully inspected before, during and after loading.

It is reported that no destruction of the bond or spalling of the lining occurred and the only apparent effect of the deformation was the appearance of a limited number of fine hair cracks of the type which have been found to readily seal under water.

Tests have also been conducted to determine the density and imperviousness of lining placed by the centrifugal machine, both for mortar mixed in the proportions of 1:2 and in the proportions of 1:1. Similar tests were conducted at the same time upon a piece of lining placed by the usual spinning method.

As will be seen by a comparison of the values of these three tests, shown in table 1, the characteristics of the lining placed by both methods are substantially the same. The sample of one to two mixture showed slightly less favorable results, and the sample of one to one slightly more favorable results, than the sample of spun lining.

APPLYING CEMENT MORTAR LINING TO EXISTING MAINS IN ENGLAND

By Thomas H. Wiggin

(Consulting Engineer, New York, N. Y.)

It was the writer's good fortune to spend about a month in England during the past summer for the principal purpose of observing the work being done for the Manchester Corporation in cleaning existing mains and lining them with cement mortar. This work was done in accordance with a process invented by Mr. William T. Tate of Sidney, Australia, and used there and in New Zealand for a number of years prior to its introduction last year into England.

The contract under which the work was being done covered the lining of about 10 miles of 3-, 4-, and 5-inch pipe, some of which was about 70 years old. This pipe in Manchester was in highly tuberculated condition. After lining, the bottom of the lining was slightly flattened, making the section somewhat of a horseshoe shape, due to the running down in the bottom of soft material squeezed out of the mortar by the mandrel.

The mandrel used in the lining of bends has a hemispherical container attached to its rear end, and the soft mortar squeezed out by the mandrel is caught in this container and removed so that the lining in bends is truly circular. The bend machine will go around any ordinary 90° bend and make a perfect lining of circular section and of uniform thickness. The lining of bends is done in the yard before the bends are laid.

At the writer's request the bend machine was used experimentally in the yard of the Manchester Corporation to observe its action in going around offsets formed by pairs of 45° bends with straight pipes between. This was a condition which had not been previously tested underground. The bend machine was found perfectly successful in making uniform lining around the reverse bands. The quality of the work was proved by subsequently separating the pipe and observing the condition and thickness of the lining in each of the fittings and pipes.

PROCESS OF LINING EXISTING PIPE LINES

The pipe was lined in stretches of from 200 to about 400 feet. The first preliminary work consisted of locating each service by record

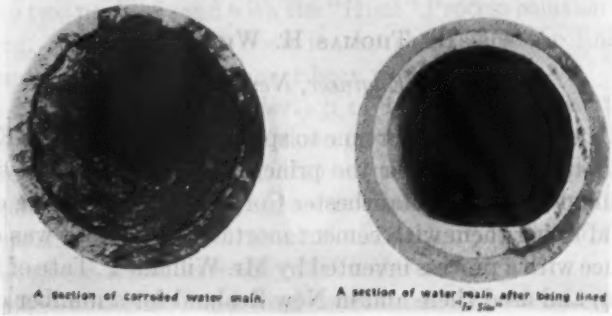
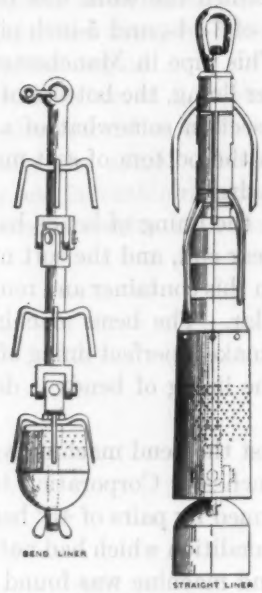


FIG. 1



—4 INCH "TATE" LINING MACHINE—

FIG. 2

measurements or in case of doubt by a so-called wireless detector fitted with ear phones. A hole about 2 feet square was dug over

each service connection and each hydrant branch, and holes were also dug at the ends of the stretch to be lined which in general would extend between cross streets. All preliminary preparations having been made, at the beginning of the day the pipe would be broken at each end of the stretch, main or corporation cocks removed, and plugs inserted. A temporary connection would be maintained at one end in order to supply some water to aid in the cleaning. At the other end a Kennedy rotary cleaner operated by gasoline engine would be inserted and advanced by feed screw. Joints of rod are added as the cleaner advances. Thus the heavy tuberculation would be bored out and the debris washed back toward the operating mecha-

FIG. 3

nism of the cleaner and, being mixed with the flushing water, would be removed from the excavation by pump. After the cleaning is completed a windlass would be set up at each end of the stretch of pipe and a prover and finisher with wire cable attached to each end would be sent through for the purpose of completing the cleaning and determining that there is no obstruction which would prevent the lining mandrel from going through the pipe. Toward the end of the 1934 work in Manchester an improved prover was used, fed by water so as to give a jet around the periphery which would thoroughly wash out any loosened debris.

In the course of the cleaning, as may be supposed, obstructions were sometimes found. For example, a long piece of lead was found

wrapped around the end of the Kennedy cleaner, indicating that the machine has real power.

At Manchester and in Australia and New Zealand the mortar is all mixed by hand. It consists of 2 parts of sand and one part of cement, the sand being finer than would be chosen for strength.

FIG. 4

Three kinds of cement have been used, viz., ordinary Portland; a quicker setting cement called Ferro-crete containing more gypsum and lime and being more finely ground than ordinary cement; and latterly so-called Ciment-Fondu, which is a high alumina cement. The mortar was mixed by hand on a steel-bottomed wooden-sided

platform. With ordinary cement the mixing was continued for about an hour while with Ferro-crete and Ciment Fondu, they being quicker setting, the mixing was continued for only about one-half hour. The consistency of the mortar is carefully controlled by slump tests. The slump is maintained at about 9 inches.

A special tee looking upward is attached to one end of the stretch to be lined and a charge of mortar is rammed into the pipe through a vertical galvanized iron tube attached at its bottom to the special tee and having a funnel at the top. The mortar either is dumped into the funnel by hand, using a pail, or is forced into the pipe by hand operated plunger. The charge of mortar is calculated so as to provide for the lining of desired thickness and leave a considerable

FIG. 5

percentage excess which will be pushed through the pipe and wasted at the end in order to be sure of a perfect lining clear to the end. A burlap bag is held by hand over the end of the pipe last to be lined in a stretch so as to give some back pressure to finish out the lining to the end. It is claimed by the inventor that a hand windlass to pull the mandrel through the pipe is the most desirable equipment as any undue strain can be felt by the operator.

The whole operation of pulling the mandrel through the pipe proceeds at the rate of about 20 feet per minute, as timed by the writer, so that it takes a very few minutes to line any stretch between streets.

The largest sized pipe existing in the ground which the writer saw lined in Manchester was 5-inch, but he saw 9- and 12-inch pipe lined in the yard with equal success.

Occasionally an obstruction is met by the prover, which can generally be pulled back by the cable attached to the rear, but sometimes gets firmly stuck. An undersized piece of 5-inch pipe, for example, had to be broken out to remove the prover.

A stretch of pipe finished in the afternoon will be put into service the next morning. In some cases a small temporary pipe is laid along the street to feed house services during the interruption. Frequently the pipe is put back into service over night after cleaning and then lined the next day, but the whole operation may be done in 24 hours. The householders along the streets appeared to be friendly to the work and in the cold weather early in the year the writer was informed they sometimes brought hot coffee to the workmen.

Considerable pressure is exerted by the mortar as it is forced ahead by the mandrel. This is indicated by the experience with hydrant branches of the English type, looking up, where the form is tapered and the mortar is forced into the annular space, making a perfect lining as the writer saw in Manchester. Occasionally a service pipe is overlooked and not disconnected. It will be filled solid full of mortar for 15 or 20 feet.

COEFFICIENTS OF FLOW

Some of these pipes had scarcely any capacity before cleaning, since the Manchester water, in common with much of the water in England and Scotland, is very soft and corrosive. At the request of the writer and under his direction several flow tests were made of the finished line. These flow tests were conducted in a manner used by our friend the late Burt Hodgman who recently left us, viz., using a piezometer pipe (in this case copper service pipe) laid along the gutter for the full length of the stretch of main to be tested so as to bring the pressures to one U-tube and eliminate all pressure gauge and spirit level errors. The water was measured through a tested meter.

The coefficients obtained were as follows:

	Coefficient of Flow (Williams-Hazen)	
Diameter of Pipe, inches	*Calculated on Nominal Diameter of Pipe*	*Calculated on Actual Diameter within lining*
3	63	148
4	88	152
5	97	142
5 (another stretch)	97	157

It will be noted that the coefficients calculated on the actual diameter are quite high, viz., from 142 to 157. The linings averaged about $\frac{5}{16}$- to $\frac{3}{8}$-inch thick. If they had been made $\frac{1}{8}$-inch thick minimum, or say $\frac{3}{16}$-inch average thickness, the coefficients calculated on the nominal diameter would have been considerably greater. A computation showed 108 instead of 88 for 4-inch pipe, and about 115 for 6-inch pipe on the same basis.

The inventor, Mr. William Taren Tate of Sidney, New South Wales, Australia, has been for many years a member of the Metropolitan Water & Sewerage Board of Sidney, and has had to do with some large storage reservoirs and aqueducts for that City, and with important business ventures as well as with the invention of pipe lining machines.

CAUSTIC WATER

Some slight trouble was experienced with causticity of the water following the putting into service of a freshly lined stretch of pipe. Mr. W. F. H. Creber, Mem. Inst. C. E., F.C.S., the chief engineer of the Manchester Corporation Waterworks, wrote that there were 2 or 3 complaints of a flat taste in the water and this was found on analysis to be due to the absence of free carbonic acid and the presence of caustic lime in the water, but that flushing out at the hydrant each morning on about 3 successive days eradicated the complaints.

Tests of water from different mains lined respectively with the three kinds of cement, viz., Portland cement, Ferro-crete, and Ciment Fondu, were made and the writer was supplied with a copy of the results. These showed a pH value after the first filling of the newly lined pipe of respectively 11.25 for the ordinary Portland cement, 11.50 for the Ferro Crete, and 9.0 for the Ciment Fondu. These results held nearly the same for 3 days in the case of the ordinary cement and the Ferro Crete, but were down to 7.5 on the second day in the case of the Ciment Fondu. The Ferro-crete showed a pH of 8 on the 5th day, and the ordinary cement 9.5 on the 14th day.

COST

All work of excavating, cutting and re-connecting cast iron pipe, disconnecting and re-connecting services, backfilling and paving were done by the Manchester Corporation. The actual cleaning and lining of pipe were done by the English Tate Company, called Tate Pipe Lining Processes, Ltd. The total cost to the City, including the Tate Company's profits, averaged 8 shillings 8 pence, or about

$2.16 per linear yard, equivalent to 72 cents per linear foot for sizes 3-, 4-, and 5-inch lumped together. There was little difference in the cost of lining these sizes, but the Tate Company preferred lining the 5-inch to the 3-inch pipe as there was less likelihood of the tools getting stuck in the pipe. The quantity of material used in lining these small pipes is insignificant so far as the cost is concerned.

Of the 8 shillings 8 pence per yard total cost to the Manchester Corporation the Tate Company received 3 shillings 6 pence per yard, equivalent to about 29 cents per foot, for cleaning and lining and made a good profit. This was the first work of the kind done in England and there were many points of inefficiency, some of which it was planned to correct in the next contract which it was stated to me by the Manchester Corporation would probably be for about 25 miles in 1935.

Conservative estimates made by the writer with the aid of the operating departments for lining certain distribution systems in New York State, including pipes from 4- to 12-inch in diameter, indicated that the work should be done at a profit, using the English methods, for about 30 to 35 cents a foot in villages where permits and paving costs would be low and services less frequent, and up to 75 or 80 cents per foot in metropolitan districts where all items of street opening work would be high.

POSSIBLE IMPROVEMENTS

In all the work so far done and in all the estimates above referred to, all service connections were removed or assumed to be removed previous to lining. The excavation, repaving, and permits for such work add greatly to the cost, and methods of avoiding the necessity of removing the services have been studied and experimented with to a slight extent with some promise of success.

It is obviously possible to substitute machine work for a part of the labor used at Manchester; furthermore the concentration of the whole work in the hands of one contractor would also permit the more economical use of labor.

For pipes with a normal amount of incrustation, cleaning could doubtless be done more cheaply and quickly by the American type of go-devil than by the rotary boring cleaner used in Manchester.

Further studies might indicate that a mortar richer in cement than the 2 sand to 1 cement used at Manchester, in Australia and in New Zealand could be made to work, although the inventor believes he

has the best mixture. A richer mortar would probably improve the coefficient. It might also increase the causticity unless special cement were used which would be advisable in any case.

The writer has suggested a way for removing the liquid mortar squeezed out of the mass by the mandrel, so that this thin mortar would not settle in the bottom and cause the slight flattened or horse shoe shape. The thin mortar is probably of greater solubility than the remainder, due to a higher cement content. No experiments, however, have been tried to test the practicability of the suggestion.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, **12**: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the journal.

Colorimetric Determination of Small Amounts of Chlorides in Waters. H. B. RIFFENBURG. Ind. Eng. Chem., Anal. Ed., **7**: 1, 14, 1935. To sample in Nessler tube is added potassium chromate indicator followed by dropwise addition of silver nitrate solution equivalent to 0.05 mg. of chloride per cc. Tube is shaken thoroughly after each addition and compared with control tube. Analyses of 20 rain water samples from Blacksburg, Va., showed maximum of 0.4 p.p.m., minimum of 0.05 p.p.m., and average of 0.23 p.p.m.—*Selma Gottlieb.*

Microdetermination of Lead. MERLE RANDALL and MARIAN N. SARQUIS. Ind. Eng. Chem., Anal. Ed., **7**: 1, 2–3, 1935. From 95 to 99 percent of lead was precipitated electrolytically as lead peroxide and remainder determined colorimetrically as lead sulfide. With from 2 to 15 mg. of lead, error was usually well below 1 percent, and was about 1.5 percent in most unfavorable cases.—*Selma Gottlieb.*

Determinations of Available Chlorine in Hypochlorite Solutions by Direct Titration with Sodium Thiosulfate. VIRGIL A. WILLSON. Ind. Eng. Chem., Anal. Ed., **7**: 1, 44–5, 1935. Sodium thiosulfate added to dilute acetic acid solution of hypochlorite is completely oxidized to sulfate, each mole of thiosulfate reducing eight equivalents of chlorine. Reaction can be used for determining available chlorine and for effecting saving in thiosulfate used as antichlor.—*Selma Gottlieb.*

A New Method for Measuring Corrosion of Metals. W. R. VAN WIJK. Ind. Eng. Chem., Anal. Ed., **7**: 1, 48–53, 1935. Extremely thin layers of metal (about 8×10^{-6} cm. thick) were sublimed onto glass plaques in high vacuum, and thickness measured by determining coefficient of light transmissibility before and after exposure to corrosive action. Experimental details are given. Measurements were made of corrosiveness of various gas oils.—*Selma Gottlieb.*

A Rapid Method for Making Standard Solutions of Specified Normality. OTTO JOHNSON. Ind. Eng. Chem., Anal. Ed., **7**: 1, 76, 1935. The solution is made of less than desired strength in trial dilution of stock solution, and after determination of normality, brought up to standard by further addition of stock solution.—*Selma Gottlieb.*

Roulette Comparator for Colorimetric Analysis. JOHN H. YOE and THOMAS B. CRUMPLER. Ind. Eng. Chem., Anal. Ed., 7: 1, 78, 1935. Standards are in Nessler tubes in revolving circular rack and sample is in adjacent stationary rack. Comparisons are made with mirror and lens system which brings images of half of bottom of sample tube and of half of bottom of adjadent standard tube into juxtaposition.—*Selma Gottlieb.*

Removal of Copper Ions from Water by Sodium Aluminate. O. J. BROCKMAN. Ind. Eng. Chem., 27: 2, 217, 1935. Copper ions were completely removed from phosphate buffer solutions at pH 5.3, or above, by coagulation with sodium aluminate, with or without addition of alum, if ratio of aluminate to copper was greater than 6.5. This method has a wider pH range than alum treatment alone.—*Selma Gottlieb.*

New Features of Design to Improve Plant Operation. J. F. LABOON. Eng. News-Rec., 113: 336, 1934. Features of new filter plants at Erie and Lancaster Pa., are outlined briefly. At former, bronze cloth screens were installed between gravel and sand in filter beds, to prevent upheaval of gravel. Site of Lancaster plant permitted installation of two wash water tanks having combined capacity slightly greater than would have been required in case of single tank, thus facilitating painting and repair.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Pipe Lines for Calgary Water Supply. WILLIAM GORE. Engineering Cont. Rec., 48: 703–6, August 22, 1934. Illustrated description of manufacture and laying of in excess of 44,000 feet of 36- and 48-inch, steel cylinder reinforced, concrete pipe for new Calgary water supply. Both sizes of pipe were of similar construction, with exception that lining in larger was reinforced with steel mesh. Joints were made with lead rings, wedge-shaped in cross-section and fiber-filled. Space on outside of joint was filled with cement grout and after laying had been completed and backfill in position for some time, joints were caulked tight from inside and space filled with mortar. Leakage under pressure 50 percent greater than that of normal operation was only from 28.61 to 63.3 gallons per 1000 feet of pipe, averaging 45.6 gallons, i.e., 6.8 percent of 667 gallons per 1000 feet allowed in specifications. Flow tests carried out on 4900-foot length of 36-inch pipe, 6 months after being placed in continuous operation, showed average coefficient of 156 in WILLIAMS and HAZEN'S formula. —*R. E. Thompson.*

Design Factors in Connection with Large Calgary Dam. Engineering Cont. Rec., 48: 831–2, September 26, 1934. Brief illustrated description of design features of Glenmore dam, one unit of new water supply system of Calgary, Alberta. Stability of structure received very severe test during winter of 1932–3, when with reservoir filling, ice adhered to face of dam, building up to depth of 6 feet. In normal operation, water level in reservoir will drop continuously during winter as storage is drawn on to meet demand.—*R. E. Thompson.*

Demands for Higher Quality Met Through Technical Advances. ROBERT SPURR WESTON. Eng. News-Rec., **113**: 336–7, 1934. Advances in art of water treatment, necessitated by more exacting demands of consumers, include use of activated carbon for removal of tastes and odors, more extensive use of zeolite softeners, improved methods of iron removal, and more general use of measures for correcting corrosiveness. In one instance, activated carbon was added to influent of slow sand filter, for removal of tastes due to algae.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

An Informative Report on Water Works Operation. Engineering Cont. Rec., **48**: 645–6, July 25, 1934. Details are given from Essex Border Utilities Commission annual report for 1933. Pre-chlorine-ammonia treatment has eliminated slime and algae growths in coagulation basins, improved structure of coagulation sludge from standpoint of removal, increased length of filter runs, and reduced wash water used nearly 50 percent. Ratio of chlorine to ammonia employed is approximately 2 to 1. Average length of filter run was 34 hours and 55 minutes, and average rate of filtration, 105.8 m.g.a.d. Average of 9 m.g. of raw water was pumped daily, 2.6 percent of which was used for wash water. Intermittent application of alum, for 30 minutes at intervals of 30 minutes, with turbidities of 10 p.p.m. or less, and for 40 minutes in each hour with turbidities of 10 to 30, gave satisfactory results. Continuous application is necessary when turbidity exceeds 30 p.p.m. Operating cost per m.g. water filtered was $13.93, of which wages $5.21, chemicals $2.24, and power $2.86 were chief items.—*R. E. Thompson.*

Recording Chlorine Consumption at the Montreal Filtration Plant. Engineering Cont. Rec., **48**: 709–11, August 22, 1934. In new chlorine control equipment at Montreal plant, chlorine consumption is recorded by loss of weight recorders connected with each of four 10,000-pound dial scales and also by electric flow meters.—*R. E. Thompson.*

Modern Waterworks Plant Replaces Obsolete System. WILLIAM L. HAVENS. Eng. News-Rec., **113**: 327–9, 1934. New water works of Conneaut, O., consisting of a lake intake, pumping stations, rapid sand filters, elevated tank, etc., which was recently constructed at cost of $270,000, is described and illustrated. Plant purchased by city in 1921 is thus replaced. Project was one of first approved by Reconstruction Finance Corporation. Purification plant consists of motor-driven mixing equipment, sedimentation basins, four 0.75-mg.d filters, 180,000-gallon clear well, and chlorination apparatus. New force mains were constructed by force-account, in order that about $10,000 in delinquent water bills could be worked out. It is estimated that cost of operation will not exceed $25,000 per year.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Wash Water Tank at Tilbury, Ontario, Filtration Plant. Engineering and Cont. Rec., **48**: 644, July 25, 1934. In 1931, town of Tilbury constructed filtration plant consisting of intake extending 3200 feet into Lake St. Clair, 2 horizontal pressure filters, 16,700-gallon ellipsoidal wash water tank, and 8-mile main connecting with existing distribution system.—*R. E. Thompson.*

Fully Equipped Hydraulic Testing Laboratory of the Dominion Engineering Works. Engineering Cont. Rec., **48**: 673–5, August 8, 1934. Illustrated description of laboratory completed early in 1933 by Dominion Engineering Works, in which full-scale tests can be conducted on pumps of capacities up to 20,000 gallons per minute, and hydraulic friction tests can be made on pipe fittings and needle, check, or other valves up to 16 inches in diameter. Provision was made for installation, at later date, of a turbine testing flume.—*R. E. Thompson.*

Water Supplies. G. M. FYFE. Surveyor, **84**: 295–6, 1933. From Chem. Abst., **28**: 549, January 20, 1934. From health point of view there is little to choose between soft and hard water. Claims have been made that children using soft water have tendency to suffer from rickets. Hard water is considered to be associated with rheumatic and gouty complaints.—*R. E. Thompson.*

Corrosion Effects of Lubricants on Bearing Surfaces. CHRISTOPHER H. BIERBAUM. Iron Age, **132**: 9, 20–1, 58, 1933. From Chem. Abst., **28**: 449, January 20, 1934. Chemical effects of different lubricants are discussed. Practically all cause corrosion of bearing, which may be beneficial if very slight and selectively directed toward softer constituents. Other forms are unfavorable and destructive.—*R. E. Thompson.*

Volumetric Method for the Determination of Barium and of Sulfates. J. C. GIBLIN. Analyst, **58**: 752–3, 1933. From Chem. Abst., **28**: 725, February 10, 1934. Place drops of solution of sodium salt of rhodizonic acid on white filter paper to produce yellow stains. Titrate sulfate solution in presence of acid with dilute solution of barium chloride until drop of solution gives red color on test paper. Results obtained by students with this procedure were good.—*R. E. Thompson.*

Determination of Small Quantities of Bromine in the Presence of Large Amounts of Chlorine and Iodine. S. H. BERTRAM. Biochem. Z., **266**: 417, 1933; cf. C. A., **27**: 4266. From Chem. Abst., **28**: 726, February 10, 1934. According to directions given in original paper, losses of iodine may occur which, however, can be prevented if during second distillation there is added a little potassium iodide dissolved in 3 cc. water + 2 drops of 4 normal sulfuric acid and 10 drops of 1 percent starch solution. Starch decreases volatility of iodine.—*R. E. Thompson.*

An Improved Micro Method of Estimating Iodine. M. PATNAIK. Indian J. Med. Research, **21**: 237–48, 1933. From Chem. Abst., **28**: 726, February 10, 1934. Modification of FELLENBURG-NEWCOMB-SANKARAN method eliminating evolution of fumes and presence of reducing substances.—*R. E. Thompson.*

The Dependence of Corrosion Velocity of Copper Upon the Thermal and Mechanical Pretreatment of the Copper. DU BOIS. Oberflächentech., **10**: 235,

1933. From Chem. Abst., 28: 731, February 10, 1934. Preliminary results show that corrosion of copper is influenced by arrangement of the crystallites, but there is difference between refined and electrolytic copper, and also between hard and soft electrolytic copper. X-ray tests revealed that soft-annealed material has oriented crystallite arrangement, hard material, unoriented. Electrolytic copper showed lower resistance against sulfuric acid than refined copper. Rolling produces differences in crystallite arrangement and therefore different corrosion resistance. It is proposed to use as definition of intensity of attack by acid on material, not the percentage loss in weight but the time required for corroding away 1 millimeter thickness from surface, previous thermal and mechanical treatment of material being stated.—*R. E. Thompson.*

A Comparison of Hardness in the Dallas Water Before and After Treatment in the City Water Plant. W. D. FRAZELL and HENRY LEWELLING. Field and Lab., 2: 8–10, 1933. From Chem. Abst., 28: 1121, February 20, 1934. Data given regarding total alkalinity and temporary and permanent hardness.—*R. E. Thompson.*

The Purification of Water by Activated Charcoal. FRANZ KRCZIL. Kolloid-Z., 65: 249–54, 1933. From Chem. Abst., 28: 1121, February 20, 1934. History of development and patent review covering methods of treating sewage, industrial waste waters, especially phenolic liquors, dechlorination, and special apparatus.—*R. E. Thompson.*

The Ecology of Sewage Fungus. R. W. BUTCHER. Trans. Brit. Mycol. Soc., 17: 112–24, 1932. From Chem. Abst., 28: 844, February 10, 1934. *Sphaerotilus natans* and its varieties are widely distributed in polluted rivers in England; they may be found in either soft or hard waters containing much organic matter (particularly effluents from beet sugar factories), with pH between 6 and 8, low sodium chloride content, and current not less than 20 centimeters per second. *Carchesium* spp. are always present when source of organic matter is sewage. *Leptomitus lacteus* occurs rarely and then usually where organic effluent enters river and becomes immediately diluted. *Fusarium aquaeductum* was observed (1) in settling pit of beet sugar factory where pH, due to lactic and butyric acid fermentations, was only 3.5; (2) in river below rayon factory, where acetate process was being used and pH was 5.0; (3) in channel conveying effluent from sewage works, where fat was extracted from sewage by means of sulfuric acid. *Beggiatoa alba* has been observed in outlets of sewers in Tees and Clyde estuaries. References number 33.—*R. E. Thompson.*

Studies of the Ecology of Rivers. I. The Distribution of Macrophytic Vegetation in the Rivers of Britain. R. W. BUTCHER. J. Ecology, 21: 58–91, 1933. From Chem. Abst., 28: 845, February 10, 1934. Data are given on distribution of macrophytic vegetation in (1) non-calcareous and acid rivers (total hardness $<$ 20 p.p.m. and average pH $<$ 6.5), (2) slightly calcareous and almost neutral rivers (hardness, 20 to 100 p.p.m. and pH 7.0 to 7.5), (3) moderately

calcareous and alkaline rivers (hardness 100–200 p.p.m. and pH 7 to 8), and (4) highly calcareous and alkaline rivers (hardness > 200 p.p.m. and pH 7.5 to 8.0). Species of vegetation occurring in each group of rivers varies somewhat with velocity of current and with original source of water. Increased nitrogen content and increased oxygen absorption capacity, resulting from sewage contamination, favor growth of *Cladophora*. References number 41.—*R. E. Thompson.*

Mechanism of the Sterilization of Water by "Verdunization." P. REISS and E. TÉCHOUEYRES. Compt. rend. soc. biol., **114**: 1046–8, 1933. From Chem. Abst., **28**: 1121, February 20, 1934. Hypochlorite equivalent to 0.1 milligram per liter added to well water having oxidation-reduction potential of +387 mv. (r_H 28.2, pH 7.4) raised potential to +584 mv. (r_H 34.5). This is high enough to kill *B. coli* and pathogenic bacteria.—*R. E. Thompson.*

Sodium Aluminate as an Adjunct to Lime-Soda Feed Water Treatment. C. N. RIDLEY. Steam Engr., **3**: 105–7, 1933. From Chem. Abst., **28**: 1123, February 20, 1934. Suspended matter (magnesium hydroxide) passing the filters after lime-soda treatment was removed satisfactorily by means of sodium aluminate.—*R. E. Thompson.*

Automatic Control Instruments Applied to the Zeolite Water Softening Process. ERIC PICK. Instruments, **6**: 215–18, 1933. From Chem. Abst., **28**: 1123, February 20, 1934.—*R. E. Thompson.*

Research on the Katadyn Method. W. GRIMMER and A. GRENTZ. Milchwirtschaft. Forsch., **15**: 367–80, 1933. From Chem. Abst., **28**: 1376, March 10, 1934. Bactericidal action is proportional to time and quantity of silver, but varies with organism studied.—*R. E. Thompson.*

Water Purification and Control. FRANK R. FILZ. Paper Trade J., **97**: 16, 29–33, 1933. From Chem. Abst., **28**: 1429, March 10, 1934. "Bottle test" and pH methods of control are compared. Optimum alum requirement is linear function of total solids and power function of alkalinity.—*R. E. Thompson.*

Analysis of Water. Anon. Paper Trade J., **97**: 18, 36–9, 1933. From Chem. Abst., **28**: 1429, March 10, 1934. Description of tentative standard methods of Technical Association of the Pulp and Paper Industry.—*R. E. Thompson.*

Comparative Investigations on the Colorimetric and Nephelometric Estimation of Phosphoric Acid. F. ALTEN, H. WEILAND and H. LOOFMANN. Z. Pflanzenernähr., Düngung Bodenk., **32A**: 33–50, 1933. From Chem. Abst., **28**: 1302, March 10, 1934. The stannous chloride-molybdenum blue colorimetric methods of (I) DENIGÉS (C. A., **15**: 218), (II) ATKINS (C. A., **18**: 3093) and (III) ZINZADZE (C. A., **24**: 5255), and the phenylenediamine-strychnine molybdenum red method of (IV) TERADA (C. A., **19**: 225) were investigated by use of Leitz universal colorimeter for absolute measurements, and the strychnine-molybdenum nephelometric method of (V) RAUTERBERG (C. A., **26**:

2141) with the Zeiss step photometer. None of methods proved entirely satisfactory with respect to speed of development, constancy, and freedom from interference by salts, etc. Colorimetrics method III and IV are best for determination of from 0.05 to 0.7 milligram P_2O_5 per 100 cc. III is unaffected by less than 10 milligrams, and IV, by less than 8 milligrams citric acid per 100 cc. Potassium sulfate up to 400 milligrams per 100 cc. did not affect IV. V is adapted to estimation of from 0.002 to 0.04 milligram P_2O_5. With less than 10γ P_2O_5, turbidity remains unchanged for several hours, but with larger amounts precipitation takes place proportionally more quickly. Up to 10 milligrams of usual salts have but slight effects. With all methods, use of freshly prepared reagents is advisable; some authors' claims that reagents are good indefinitely were disproved. Twenty-four references.—*R. E. Thompson.*

(Water) Sterilization by the Use of Chlorine and Chlorine Compounds Resembles a Simple Oxidation Effect. Ed. Imbeaux. Rev. hyg. méd. prévent., **55**: 696–9, 1933. From Chem. Abst., **28**: 1431, March 10, 1934. After discarding other theories, author concludes that sterilizing power varies with oxidation potential, same factors influencing both. Bacterial reduction parallels oxidation potential (in volts) with chlorine, chloramine, and azochloramide. Similarly, addition of ammonia reduces both oxidation potential and sterilizing power of chlorine. Between 0° and 25° there is gradual increase in sterilization and in oxidation potential: With increasing turbidity, there is decrease.—*R. E. Thompson.*

The Budenheim Process of Water Softening with Trisodium Phosphate. P. Köppel. Papier-Fabr., **31**: Tech.-wiss. Teil, 109–11, 1933. From Chem. Abst., **28**: 1432, March 10, 1934. Correction of abstract in C. A., **27**: 4861. Feed water is preheated, mixed with alkaline water drawn from boiler, and phosphate added. Heating removes gases and 30 per cent of calcium bicarbonate; sodium hydroxide from alkaline water drawn from boiler removes remaining bicarbonate, resulting sodium carbonate and the sodium carbonate of the boiler water remove most of calcium sulfate; and phosphate removes all remaining incrustants, especially residual soluble calcium carbonate. One hour is required when 15 grams phosphate per cubic meter per degree hardness is used. With water harder than 30°, preliminary soda-lime treatment is recommended.—*R. E. Thompson.*

Copper and Health. W. M. G. Schneider. Cuivre et Laiton, **6**: 519–26, 1933. From Chem. Abst., **28**: 1434, March 10, 1934. According to recent research, copper and brass are absolutely safe for piping drinking water. Admissible amount of copper in drinking water is 5 milligrams per liter. Greater amount makes taste disagreeable. Sewer pipes of copper are safe even for acidic sewer waters if pH is about 6.5 and copper content, about 0.5 milligram per liter. Use of copper sulfate to prevent development of microörganisms in water reservoirs is not harmful to health. Fifteen references—*R. E. Thompson.*

The Chemical Aspects of the Purification of Water and Sewage. H. B. TAYLOR. Chem. Eng. Mining Rev., **26**: 139–42, 1933. From Chem. Abst., **28**: 1434, March 10, 1934.—*R. E. Thompson.*

The Theories of Corrosion. O. A. KNIGHT. Mineral Ind., Penna. State Coll., **3**: No. 2, 2, 4: No. 3, 2, 4, 1933; No. 4, 3–4, 1934; cf. C. A., **28**:86. From Chem. Abst., **28**: 1647, March 20, 1934. Review of the acid, film, peroxide, direct oxygen attack, colloidal, biological, and electrochemical theories of corrosion. Soil corrosion and methods of combating atmospheric corrosion are discussed.—*R. E. Thompson.*

Comparative Investigations on Methods for Nitrate Determination. F. ALTEN and H. WEILAND. Z. Pflanzenernähr., Düngung Bodenk., **32A**, 337–48, 1933. From Chem. Abst., **28**: 1629, March 20, 1934. The phenolsulfonic acid methods (I) were not investigated, as their characteristics are well known. Diphenylamine method of TILLMANS and SUTHOFF (cf. C. A., **5**: 3211) was fairly accurate for from 1 to 2.5 p.p.m. nitrate and is not affected by chlorides. Brucine method of AUTENRIETH and FUNK (cf. C. A., **7**: 3627) gave variable results at different times; use of reagent preserved with chloroform was especially unfavorable. The 2,4-xylenol method of BLOM and TRESCHOW (cf. C. A., **23**: 4994) has theoretical advantage over I that but one nitration product is likely to be formed. Tests indicated that it is capable of good results under favorable conditions, which include absence of organic matter, as from plant extracts, lead, manganese, or halide salts, although small amounts of acetic, oxalic, and phosphoric acids and of ethyl alcohol were harmless. Following modification of original method is recommended: Evaporate the alkaline sample solution to dryness in flask, and add 0.2 cc. 2,4-xylenol and 50 cc. cold dilute sulfuric acid (5 volumes concentrated acid with 3 volumes water); or, omit evaporation, adding concentrated acid in proper ratio with cooling during addition; if N_2O_5 exceeds 10 milligrams, use more acid mixture in proportion. Stopper and shake until evaporation residue is detached from flask. Keep on sand bath at 50° with frequent shaking for 4 hours, or overnight. Cool before opening flask, pour into 500- or 750-cc. distilling flask and rinse nitrating flask with dilute sodium hydroxide and water to 400 cc. volume. Distil with low flame into 250-cc. volumetric flask containing 25 cc. normal sodium hydroxide kept cold. When receiver is nearly filled, arrange apparatus so as to allow condenser to heat, to drive over any nitro compound adhering. Make up to volume at 20° and compare in colorimeter with about same quantity of nitrate standard carried through the process. Use of 5-nitro-2,4-xylenol standard of BLOM and TRESCHOW gave inconsistent results; only 70 to 80 per cent of theoretical.—*R. E. Thompson.*

Colorimetric Methods for Nitrate Determination in Water. WALTER LÜHR. Z. Untersuch. Lebensm., **66**: 544–56, 1933. From Chem. Abst. **28**: 1797, March 20, 1934. It is shown that method of GRANDVAL and LAJOUX for colorimetric determination of nitrate, wherein dry residues are treated with phenolsulfonic acid in open porcelain dish, results in significant losses. These may be avoided

by adding 2 drops 15 percent sodium hydroxide to 10 cc. water to be evaporated and through use of flasks. While this method gives serviceable results, it is considered inferior to methods of NOLL and TILLMANS-SUTTHOFF because it is more troublesome and less sensitive.—*R. E. Thompson.*

The Action of Bacteria in the Thermal Springs of Aachen and Aachen-Burtscheid. A. BRUSSOFF, F. REINARTZ and A. SCHLOEMER. Z. Untersuch. Lebensm., **66**: 446–53, 1933. Chem. Abst. **28**: 1798, March 20, 1934. Lime deposits in 2 thermal springs are of bacterial origin. Silica-depositing and iron-storing bacteria are also involved in its formation.—*R. E. Thompson.*

Standardization of Thiosulfate Solution with Potassium Dichromate as a Standard. ZINZIRO NAKAI. Bull. Fishery Expt. Sta. Gov. Gen. Chosen, Ser. D, No. 3: 1–24, 1933. From Chem. Abst. **28**: 1947, April 10, 1934. (Abstracts in English.) Study of errors involved in standardization of thiosulfate solutions against potassium dichromate leads to following conclusions: Weight of potassium iodide used should be less than 11 × weight of dichromate taken, and weight of hydrochloric acid less than 51 × weight of dichromate. Potassium iodide content should be at least 0.6 per cent; hydrochloric acid, greater than 3 per cent; and liberated iodine, about 0.08 per cent. Titration should take place below 30° and in diffused sunlight.—*R. E. Thompson.*

Simple Water Analysis. H. G. SMITH. Can. Mining J., **55**: 14–17, 1934. From Chem. Abst., **28**: 2083, April 10, 1934. Simple routine water tests described are sufficiently accurate to ensure correct softening of water for all purposes.—*R. E. Thompson.*

Improvements on Winkler's Method for Determining Oxygen in Sea Water. ZINZIRO NAKAI. Bull. Fishery Expt. Sta. Gov.-Gen. Chosen, Ser. D, No. 3: 25–42, 1933. From Chem. Abst., **28**: 1953, April 10, 1934. Chief improvements are use of 100-cc. samples, obtained by dissolving manganous hydroxide precipitate with hydrochloric acid, use of reagents of standard strength and volume for standardizing thiosulfate solution, and use of table for conversion of titrated values to oxygen values. Comparison of different methods of standardizing thiosulfate solution showed that VOLHARD's method gave variation of 4 to 7 percent, while those of WINKLER-BJERRUM, KROGH, or of author, gave only 0.4 percent variation. **Some Experiments on Winkler's Method for Determining Oxygen in Sea Water.** Ibid., 43–8. A few helpful suggestions are given. **Method of Determining Oxygen in Sea Water Adopted in Our Station.** Ibid., 49–62. Detailed description of method.—*R. E. Thompson.*

Nephelometry. I. Analysis of Potable Waters. LUIGI BELLADEN, UGO SCAZZOLA and RENATO SCAZZOLA. Ann. chim. applicata, **23**: 509–16, 1933. From Chem. Abst., **28**: 2083, April 10, 1934. Nephelometric methods have been applied to determination of sulfate, chloride, calcium, and magnesium. Chloride is readily determined to 1 part in 10 million with proper illumination. Addition of glycerol does not help in sulfate determination, low limit being about 7 parts per million. Calcium is determined according to RONA and

KLEIMAN (C. A., 17: 3351), using sodium sulforicinate as precipitant. Calcium and magnesium are then determined according to FEIGL and PAVELKA (C. A., 19: 797) with potassium ferrocyanide and ammonium chloride, solution for comparison containing amount of calcium as found above, magnesium being determined by difference.—*R. E. Thompson.*

Production of "Distilled Water" by Electroösmosis. II. R. DIETZEL. Pharm. Ztg., 79: 71–2, 1934; cf. C. A., 26: 2896. From Chem. Abst., 28: 2437, April 20, 1934. Illustrated experimental study giving values obtained with 3 samples of water over periods of 35, 27, and 25 days respectively.—*R. E. Thompson.*

Internal Attack of Water Mains. K. ADLOFF. Wärme, 56: 265–8, 1933; Chimie et industrie, 30: 1070–1. From Chem. Abst., 28: 2085, April 10, 1934. Corrosion of water mains is due chiefly to thin film of water which adheres strongly to pipe, and depends on oxygen content and acidity and on velocity of water in pipe. When latter is very high, as in case of main pipes as compared with small branches, corrosion is slight, or nil, because adherent film is carried away by current. Two methods are used to remove dissolved carbon dioxide: (1) water is allowed to flow over marble; this process is not effective for waters above certain degree of hardness; (2) saturated lime water is added in amounts depending on total hardness. After latter treatment has been applied for some time, inside of mains becomes covered with protective coating which prevents corrosion and lime dosage may be reduced.—*R. E. Thompson.*

The Hygienic Value of the Disinfecting of Swimming Water by Means of Chlorine, Chloramine and Copper Chloride. J. IDZERDA and J. H. WILDERVANCK. Nederland. Tijdschr. Geneeskunde, 77: IV, 5091–5101, 1933. From Chem. Abst., 28: 2086, April 10, 1934. Ordinary chlorination is preferable in continuous system of purification, provided (1) that circulation period does not exceed 8 hours, (2) that number of visitors does not exceed allowable limit, and (3) that water is suitable. Chloramine is to be used for "periodical" systems. Combined copper and chlorine method is unreliable and requires too much supervision.—*R. E. Thompson.*

Permeability of Concrete Under High Water Pressure. CORNELIUS C. VERMEULE. Civil Eng., 3: 611–4, 1933. From Chem. Absts., 28: 2151, April 10, 1934. Mix of 1:2:4 is necessary to secure water tightness in walls 2 feet thick even under light pressures; but this mixture is also sufficient up to 200-pound pressures. Hydrated lime up to 10 per cent gave tighter more compact mass. Tables given showing absorption and leakage from 50 to 200 pounds.—*R. E. Thompson.*

Sanitation and Water Purification. J. H. GARNER. Reports of the Progress of Applied Chemistry (issued by Society of Chemical Industry, London) 18: 1933, pp. 679–710. Review of progress in water purification, sewage disposal, and conservation of rivers. Economy has limited expenditure and proposal of grid principle analagous to electricity grid has been severely criticised.

Plankton and algal troubles are dealt with, good aëration and circulation in reservoirs is advocated; if pH of filtered water is above 6.3, even heavy doses of copper sulphate will not reach filters when alum treatment used. Prefiltration processes have extended owing to better understanding of chemistry involved, and modern American practice is cited on floc formation, periods and velocities of agitation and spiral flow. Dealing with chloramine process reference is made to questionnaire issued to 200 waterworks by W. J. ORCHARD (J. A. W. W. A., 1933, **25**: 390) and to L. H. ENSLOW's suggestion to prechlorinate and then to ammoniate excess chlorine. Use of activated carbon to remove color, taste, odor, and excess chlorine is extending; general trend being to apply finely divided carbon prior to filtration, and again American practice is quoted. Treatment of swimming pool waters has increased; coagulation, filtration, aëration, and chlorination being common practice, with complete turnover of water in 3 to 4 hours for indoor, and in 6 to 8 hours for outdoor pools, controversial point being whether chlorine alone is better than chloramine treatment, since rapid sterilisation is required. Pure water for industrial purposes is also discussed and various softening processes are mentioned, e.g., lime-soda and sodium aluminate, trisodium phosphate, disodium phosphate and ammonia, while American work on sulphate: carbonate ratio in boiler water is mentioned. Review concludes with some 12 pages dealing with sewage disposal.—*W. G. Carey.*

The Distribution and Sanitary Significance of B. Coli, B. Lactis Aërogenes, and Intermediate Types of Coliform Bacilli in Water, Soil, Feces, and Ice Cream. D. A. BARDSLEY. Journal of Hygiene, **34**: 1, 38–49, February, 1934. Investigations were made on 5181 strains of coliform origanisms from water, soil, human feces, and ice cream, all being Gram-negative, fermenting lactose, and clotting milk. Methyl red (**M. R.**), Voges-Proskauer (**V. P.**), citrate, uric acid and indol tests were employed, intermediate type of organism being **M. R.** +, **V. P.** +, citrate +, uric acid −, indol −. 4297 strains from waters included 2,947 *B. coli*, 556 aërogenes, and 581 intermediate. Over 50 percent of intermediates showed weak clotting, and delayed gas formation from lactose, and were generally shorter and thicker than *B. coli*. Proportion of coli to aërogenes was 10 to 1 in town supplies, 3 to 1 in rural supplies, 4 to 1 in lakes and streams, and nearly 1 to 1 in swimming pools. Chlorination may destroy **M. R.** + organisms more rapidly than **M. R.** −. MACCONKEY presumptive test proved very reliable, for out of 1102 positive presumptives, only 15 percent failed to confirm; confirmatory tests, therefore, might well be discarded in ordinary sanitary examinations. In soils examined, 31 percent showed *B. coli*, 2.6 percent aërogenes, and 66.4 percent intermediate; these results do not confirm previous observations that aërogenes is dominant in unpolluted soils. *B. coli* was dominant organism in 34 samples of human feces examined, 78 percent being coli, 12 percent aerogenes, and 9 percent intermediate.—*W. G. Carey.*

Report of the Copper Pipe Committee. Water and Water Engineering, **36**: 437, 496–497, August, 1934. Results since 1928 at 12 Waterworks in Netherlands with dune, river, and ground waters are given. Tinned pipes must have

non-porous layer of tin and have not less than 30 gms. tin per sq. meter covered. Copper dissolved by 2 percent ammonium persulphate in 30 minutes must not be more than 0.5 mgm. per 100 square centimeters of tinned surface and lead content of tin must not exceed 0.5 percent. It is generally considered that the small amounts of copper dissolved from copper pipes have no bad effect upon health; but maximum is fixed at 3 mgm. per litre after 16 hours contact; this amount causes no unpleasant taste in water, beverages, or food. In only one case was copper over this amount, and no danger arises from copper carrying from 0.25 to 0.45 percent of arsenic. Amount of copper dissolved is affected by carbon dioxide content, and copper is found to be slightly less soluble in warm than in cold water. Use of untinned copper is not permissible if pH is 6.9 or lower, or if dissolved oxygen is more than 3 mgm. per litre; but tinned copper may be used.—*W. G. Carey.*

NEW BOOKS

Vom Wasser; Ein Jahrbuch für Wasserchemie und Wasserreinigungstechnik, VIII Band: 1934. 420 pp. Verlag Chemie, G.m.b.H., Berlin. W. 10. Obtainable in two Parts, I dealing with water supplies, mineral waters and sewage, II with corrosion and boiler feed water. **Part I. Standard Methods for Physical and Chemical Examination of Water.** H. Stoof. 3–5. Standard methods pamphlets published by Verein Deutscher Chemiker (J. A. W. W. A., 26: 1, 161, January 1934) are being modified and reissued as loose leaf sections which can be altered and enlarged as necessary. Sections are (**A**) general, sampling, expression of results; (**B**) taste and odor tests; (**C**) physico-chemical examination; (**D**) determination of anions; (**E**) of cations; (**F**) of non-electrolytes; (**G**) of dissolved gases; (**H**) gas-producing substances. Methods for qualitative and quantitative examinations are to be included, with their sensitivity and probable error. **Present Day Problems of Mineral Water Chemistry.** R. Fresenius. 6–13. Analyst of medicinal waters should look for traces, e.g. of caesium and of rubidium, and for evidence of radioactivity. Spectrum analysis has assisted in determination of minute traces of substances, and radioactivity investigations make it possible to estimate amount of emanations, but effect of radium action on substances present and also effect of colloids upon dissolved ions need further study. The relationship between action of medicinal waters and their chemical composition is not well understood. **Quantitative Determination of Radium Emanation.** P. Sander. 14–22. Advances during past thirty years are discussed, and emanometer of Becker is described, with improvements. Comprehensive bibliography is also given. **Treatment of Drinking Water in Königsberg.** F. Hurdelbrink. 23–31. Until 1928, town's only supply was from series of ponds, but since then, augmented by Pregel water. Both supplies are treated in settling tanks and with rapid filters, pond supply being also filtered through slow sand filters. At low temperatures, ferrous sulfate is better coagulant than alum; but color removal is not so good. With ferrous sulfate partially oxidised by chlorination, coagulation was possible at lower pH and color removal was better. Activated carbon has been used satisfactorily on filters, and water is to be treated in tank with powdered carbon kept in suspension by aëration. **Problem of Iron Re-**

moval from Humic Waters. W. HECKMANN. 32–37. Iron removal from humic waters is complicated by organic matter acting as protective colloid, or by adsorption. Potassium permanganate so acts upon organic matter that it no longer adversely affects iron removal; while permanganate causes no alteration of pH value of water. Manganese dioxide thus formed is necessary for manganese removal, for which pH control is required. Suitable methods of iron removal must however be found experimentally in each case. **Influence of the Lime-Carbon Dioxide Equilibrium.** R. SCHMIDT. 38–43. Work of TILLMANS and HEUBLEIN on lime-carbon dioxide ratio was with pure calcium bicarbonate-carbonic acid solution; but resulting formula evolved is equally applicable to naturally occurring waters. If water contains large amounts of calcium sulfate, magnesium bicarbonate, or sodium bicarbonate, free carbon dioxide is better calculated by later formula of TILLMANS or by that of KOLTHOFF. **Corrosion in Sea Water by the Action of Lower Organisms.** C. BÄRENFÄNGER. 44–48. Bacteria and fungi promote corrosion in sea water; but a benzyl cellulose varnish made by Frenkel of Leipzig-Mölkau affords protection It is not claimed to inhibit growth of algae etc.; but it prevents their penetration. This varnish will also protect ironwork in water purification plants dealing with corrosive waters. **Report of a Visit to Troisdorf Sewage Works.** H. STOOF. 49–54. Account of sewage works comprising two Travis settling tanks having colloid traps with sludge collecting tank between, four digestion tanks, and 360 square yards of sludge drying beds, plant being made to treat up to 1.3 million gallons (U. S.) dry weather flow in 14-hour day. **Discharge of Waste Water into the Sea.** C. BÄRENFÄNGER. 55–58. Research on effect of sewage and industrial wastes on sea water is needed. Conditions differ from those in river discharge and tides, wind, salt content, and biological conditions all affect sewage; while discharge has effect on flora and fauna of sea. **Utilization of Wastes.** F. SIERP. 59–66. Investigation on recovery of materials from trade wastes and sewage is needed. Sugar, proteins, fats, resins, and phenols are destroyed to make discharge innocuous; but recovery by concentration or conversion should be investigated. **New Possibilities for the Chemical Treatment of Sewage.** H. JUNG. 67–84. Methods described are (1) electrolysis, using iron electrodes, which in alkaline sewage form iron hydroxide as coagulant; stream of finely divided air facilitates process; (2) in presence of iron, carbon dioxide and air are blown through sewage, final product is again ferric hydroxide as coagulant; and (3) treatment with ferric salts, air, and carbon dioxide has similar effect. **Biological Decomposition of Phenol.** F. SIERP and F. FRÄNSEMEIER. 85–107. Bacteria present in effluents and streams are chiefly responsible for phenol decomposition; intermediate products have not been identified; but carbon dioxide and water are end products of decomposition. Efforts have been made to explain connection between **B.O.D.** and carbon dioxide formation when phenol present, and effects of sewage, river sludge, and temperature on phenol decomposition are described. **Estimation of Phenol.** R. CZENSNY. 108–115. Color is formed by coupling phenol with diazotised nitraniline. Using *p*-nitraniline, phenol gives orange yellow; 0.01 mg. can be detected. For cresol, or mixed phenol, *m*-nitraniline is preferable. **Estimation of Phenol in Water and Waste Water.** F. MEINCK and M. HORN. 116–125. In bromination methods, inaccuracies occur because

all phenolic substances do not behave in same way on bromination. Separation by volatility in steam leads to error, because sharp separation is impossible. Colorimetric methods give approximate results only, because standards are often of different composition from samples. **Experiments on the Treatment of Trade Wastes by Activated Sludge.** E. NOLTE, H. J. MEYER and E. FROMKE. 126–147. Experimental activated sludge plant (70 litres) working on HAWORTH principle is described and illustrated, and its results with beet factory wastes are discussed. **Treatment of Wastes from Starch Factories.** W. HUSMANN. 148–162. Fluming and washing waters contain mainly mineral matter and are treated by settling and chlorination. Other wastes contain mainly dissolved organic matter and must be treated in trickling filters, aërated filters, or contact aërators, by activated sludge process, or by electrolytic treatment. **The Effect of Wastes Containing Copper upon Streams, and its Detection.** R. CZENSNY. 163–168. Copper is poisonous to fish; but 1 mg. per litre is in general harmless and cases of fish destruction are few. Water-borne copper is stored in plants and author detects copper in streams by ashing plants and determining their copper content. Method recommended is that of SPAKU; to 25 cc. of water are added 15 drops 20 percent ammonium thiocyanate, 10 drops of pyridine, and 0.5 cc. chloroform; after shaking, green color extracted with chloroform is compared with standards. **Detection of Copper in Drinking and Pool Waters.** R. KROKE. 169–172. Method of SPAKU (see above) is not suitable for waste water containing colloids. For ordinary water, author uses 500 cc. water, adding 0.5 cc. concentrated sulphuric acid, 20 cc. 10 percent thiocyanate, 3 cc. pyridine, and 55 cc. chloroform. Green chloroform extract is filtered through dry filter and compared immediately with standard of copper sulphate, potassium dichromate, and sulphuric acid. **Part II. Feed Water Requirements for High Pressure Boilers.** A. SPLITTGERBER. 3–41. Sections included are those dealing with distillation and de-gassing; solution of iron in pure, oxygen-free water; corrosion of boiler shells by oxygen; phosphate treatment of water; salt concentration of boiler water; removal of organic substances; silica content; carbon dioxide content; base exchange softening; de-oiling of water and estimations of dissolved oxygen, phosphate, and hardness. Condensate plus distilled water make-up is advisable for high pressure boilers; but chemically prepared water is also possible which will cause neither foaming, priming, silicate scale, nor corrosion; base-exchange softening is in general the best method for such chemical treatment. **Critical Examination of Feed Water Treatment Using Return Boiler Water.** H. LIANDER. 42–56. Deals with following items: fundamental principles; calculation of amount of boiler water to be returned to add definite amount of sodium carbonate or hydroxide to softening plant; decomposition of soda in boiler at different concentrations and temperatures; regulation of soda number and of carbonate:sulfate ratio to prevent scale formation and embrittlement; prevention of foaming and priming by regulation of returned water; effect of return water on sludge settlement in boiler; and use of trisodium phosphate with return water. **The Amount of Phosphate Required for Secondary Softening.** W. WESLY. 57–66. Description, with illustration of apparatus used, of laboratory reduction by phosphate of residual hardness after lime-soda softening. When trisodium phosphate alone is used

it reacts with hardness in ratio of 1 P_2O_5 to 3.3 CaO. Amount of phosphate required to reduce residual hardness to minimum (1.2 to 1.5 mg. CaO per litre) decreases with increasing alkalinity of softened water. About 17 mg. P_2O_5 per litre per degree of hardness is required for minimum hardness, using phosphate alone, and excess phosphate is found in solution. **The Reaction of Trisodium Phosphate with Hardness-Substances in Aqueous Solution.** A. HAENDELER. 67–76. Less phosphate is required for softening in practice than amount calculated. Different types of precipitate do not appear to exert appreciable effect on amount of phosphate required, more important is thermal decomposition of bi-carbonate present and reaction of phosphate with bicarbonate. One equivalent of trisodium phosphate precipitates two equivalents of hardness; one as phosphate and one as carbonate or hydroxide. **Chemical Removal of Boiler Scale.** G. AMMER. 77–92. Scale may be removed with acid alone, e.g. formic, acetic, or citric acid, or with very dilute inorganic acid; with hydrochloric acid and a protective substance, e.g. glue, gelatine, dextrin, potato starch, egg albumin, sulphite waste liquor, etc.; with an electric current; or with alkaline reagents, e.g. sodium carbonate, caustic soda, or trisodium phosphate. A list of 41 references to patent and other literature is given. **Conductivity Measurements as Indicators of Hardness in Softening Plants.** L. W. HAASE. 93–110. Measurement of conductivity of solutions is dealt with in relation to softening, whether thermal, with lime or by lime-soda process, with phosphate, or by base exchange. In thermal softening conductivity before and after varies with hardness and is unaffected by other components of water, 25 reciprocal ohms corresponding to one hardness degree (German). Using lime only, softening process can be controlled by conductivity differences and is unaffected by excess reagents, or neutral salts. Lime-soda process can be controlled by conductivity provided some carbonate hardness is present, but conductivity measurements are unsuitable for phosphate softening. Base exchange softening does not appreciably affect conductivity, but may be controlled if lime water or soda is added, so that when zeolite is exhausted alkaline substance will react with hardness and conductivity decrease. **Hot Water Corrosion and Its Prevention.** L. W. HAASE. 111–123. Water in hot water systems for domestic use is heated to from 50 to 85°C. and corrosion problems differ from those in boiler plant. Corrosion is promoted by electrochemical activity causing solution of metal and is accelerated by unsuitable material, incorrect construction of plant, and wrong method of operation. Behaviour of iron, galvanized iron, copper, tinned pipes, and pipes with other protective coatings, in hot water conditions, is exhaustively dealt with. Methods of operation, with illustrations of suggested plant, are given and methods of deoxygenation of water, mechanically and chemically by sulphite addition, are also described. **The Chemist as Corrosion Expert.** F. TÖDT. 124–133. Discusses importance of corrosion problems, e.g. expense caused thereby, and stresses work of chemist. Action of oxygen; position of metal in E. M. F. series; formation, affinity, and solubility of oxide film; local current theory; passivity of metals; and making and interpretation of corrosion tests are dealt with. **Simple Method for the Rapid Determination of Silicic Acid in Boiler Feed Water in the Presence of Phosphate.** G. AMMER. 134–137. Phosphate-molybdate color is less stable than silicate-molybdate color and is

destroyed by oxalic acid. To 100 cc. of sample are added 1 gm. of ammonium molybdate, 3 cc. hydrochloric acid (1 concentrated acid to 3 water) and, after 5 minutes, 10 cc. of 10 percent aqueous oxalic acid, shaking vessel. After 3 minutes, color is compared with standard made from 0.53 percent aqueous potassium chromate, or from 0.06 percent aqueous picric acid, added dropwise until color matches that of 100 cc. of sample diluted to 113 cc. with distilled water. Picric acid color matches silicic acid color better than does potassium chromate. Samples containing over 200 mg. per litre P_2O_5 or over 20 mg. per litre SiO_2 should be diluted. **Estimation of Hardness in Waters with Low Hardness Content.** G. AMMER. 138–153. BOUTRON and BOUDET'S, SEYB'S and SPLITTGERBER'S methods of hardness estimation with soap solution are compared with gravimetric results. In two latter methods water is first neutralized to phenolphthalein and BOUTRON and BOUDET'S soap is diluted 10 and 5 times, respectively, with 56 per cent by volume alcohol. Values with SEYB'S and SPLITTGERBER'S methods agree with one another and with gravimetric figures when dealing with tap water; but discrepancies are found with boiler and softened water; for these, BOUTRON and BOUDET'S method gives results nearer gravimetric. Chlorides and sulfates affect soap methods, results being lower than gravimetric with high content of salts and higher, with low salt content. Table shows optimum chloride-sulfate content for obtaining agreement between soap and gravimetric results (e.g. 90 mg. per litre chloride-sulfate for 0.3 German degrees and 350 mg. per litre for 2 German degrees) and sodium chloride may be added to sample accordingly. Turbid waters should be filtered, since neutralization with acid may cause suspended matter to dissolve and so affect hardness, and colloidal matter should be removed by activated carbon. Neutralization to red with phenolphthalein prevents interference by aluminum present after flocculation with alum. **Oxygen Absorbed Determinations, Especially in Presence of Humic Acids.** H. DÖRSAM. 154–160. Objections to oxygen absorbed determinations with permanganate in alkaline solution are disposed of, and alkaline method advocated, as well as use of acid method for comparison. With water containing humic acids, it is found that determination in alkaline solution is not affected by chloride or by amount of excess permanganate, whereas both influence results with acid method. Experiments do not justify complete replacement of acid method by alkaline; latter for example gives too high results with manganese waters. **A Color Reaction for Calcium, Strontium, and Barium.** G. AMMER and H. SCHMITZ. 161–168. Blue color is formed on adding to neutral aqueous solution of alkaline earth salts 2 drops of 2 N sodium hydroxide and 1 drop of 10 percent tannic acid (with addition of 0.1 percent salicylic acid to prevent fungoid growth) and may be compared with standards prepared at same time. Color changes in between 3 and 5 minutes to yellow or brown, and with alkaline earth concentrations above 100 mg. per litre precipitation occurs. Reaction is affected by large amounts of magnesium, or of heavy metals, but these may be removed by suitable means. Ratio of magnesium to calcium in waters is usually small, so that calcium hardness may be determined by this method. Colorimetric method gives results higher than gravimetric with low calcium hardness, and lower, with high calcium. **Observations on Analysis of Condensates.** E. SEYB. 169–172. For evaporation of condensates for solids de-

terminations, porcelain basin loses weight on heating on water bath, and waters with low salt content attack glass and therefore increase residue. Evaporation in platinum dish over open flame is advocated, using 2 litres of water (10 litres if salinity less than 2 mg. per litre). Lime is precipitated as oxalate and titrated with N/100 permanganate, sulfate is weighed as barium sulfate, and chloride is titrated with silver nitrate by MOHR's method. **Decomposition of Sodium Bicarbonate in Aqueous Solution.** A. SPLITTGERBER. 173–177. Sodium bicarbonate is partly dissociated in aqueous solution and is practically stable only in presence of free carbon dioxide, when only 0.04 percent is dissociated. Loss of carbon dioxide occurs above 20°C. and decomposition of bicarbonate is accelerated by increasing temperature, pressure, and concentration, but is retarded by sodium carbonate produced. Formula expressing equilibrium between bicarbonate, carbonate, carbon dioxide and water is given. Aqueous sodium carbonate will absorb carbon dioxide on cooling, and this is of importance in finding alkalinity of boiler waters. **Determination of Alkalinity (Hydroxide and Carbonate) and Soda Number in Boiler Waters.** R. MÜLLER. 178–180. One hundred cc. of clear sample are titrated with $N/10$ hydrochloric acid until neutral to phenolphthalein (p) and then until acid to methyl orange (S). Air is aspirated through solution to remove liberated carbon dioxide and solution back titrated with N/10 NaOH until alkaline to phenolphthalein (L). Then, NaOH, in mg. per litre, is $[2p + L - (S + 0.20)]$ 0.40 and Na_2CO_3, in mg. per litre, is $[S + 0.20 - (p + L)]$ 0.106, the 0.20 being taken as an average blank figure. **The Examination of Boiler Sludge and Scale Containing Phosphate.** R. MÜLLER. 180–181. After fusion with sodium carbonate and usual treatment with hydrochloric and nitric acids, silica is filtered and weighed. Phosphate is precipitated in part of filtrate with molybdate, this precipitate being dissolved, precipitated with magnesia mixture, and weighed as pyrophosphate. Two separate equal portions of silica filtrate are mixed with known amount of standard iron solution and iron, aluminum and phosphate precipitated using sodium acetate (BILTZ, Aüsfuhrung quantitativer Analysen, p. 161), one precipitate being ignited and weighed. Iron in second precipitate is reduced with stannous chloride in presence of manganese sulfate and phosphoric acid (ZIMMERMANN-REINHARDT) and titrated with permanganate. Aluminum oxide is obtained by difference, from weight of ignited precipitate and determined phosphate and iron. In one of acetate filtrates calcium is determined as oxalate and magnesium as pyrophosphate, while in second acetate filtrate, sulfate is determined as barium sulfate. Alkali metals are determined as chlorides in usual way in a fresh portion of sample. **Automatic Recording Apparatus for Boiler Water Control.** A. SPLITTGERBER. 182–187. Density, or salinity, is determined by electrical conductivity measurements; dissolved oxygen, by electrolytic combination with hydrogen; alkali, by automatic titration with acid; and hardness, by effect of turbidity produced with soap solution upon light directed on to thermopile. Diagrams of existing apparatvs are given. **Comparative Chemical Investigations of the Determination of Sulfate in Boiler Water by Different Methods.** R. MÜLLER. 188–202. Four methods are compared: (1) MÜLLER's drop method, in which sulfate is precipitated with barium chloride, excess of which is titrated in ammoniacal solution with dichromate, using *p-p'*-diaminodiphenylamine indicator paper; (2) SEYB's method in which sulfate is

precipitated in cold acid solution with barium chloride; solution after neutralization is shaken with excess sodium carbonate and back titrated with hydrochloric acid; (3) AMMER-SCHMITZ method (J. A. W. W. A. 26: 9, 1311, September 1934) in which sulfate is precipitated with $N/10$ barium chloride and excess titrated with $N/10$ potassium palmitate; and (4) RASCHIG-KOLTHOFF method in which sulfate is precipitated with benzidine dissolved in hydrochloric acid, resulting precipitate filtered off, dissolved in warm water, with addition of alcohol to dissolve free benzidine, and titrated with $N/10$ sodium hydroxide, using phenolphthalein. (1) and (4) gave best results; but (1) necessitates removal of phosphates by ferric chloride and sodium acetate, whereas (4) is unaffected by phosphates or by dissolved organic matter. **Physico-Chemical Investigations of Calcium Carbonate Deposition from Water.** R. STUMPER. 203–224. Carbon dioxide-water system, solubility equilibrium of calcium carbonate, dynamics of calcium carbonate deposition are first dealt with theoretically. Experimental work is described and comprises results obtained for decomposition of calcium bicarbonate solution by air stream both without calcium carbonate addition, and also with addition of varying amounts of amorphous and crystalline calcium carbonate; and influence upon this decomposition of foreign substances, e.g. zinc, cobalt, iron, aluminum, graphite, etc.—*W. G. Carey.*

Elements of Water Supply Engineering. EARLE LYTTON WATERMAN. John Wiley and Sons, Inc., New York, New York. 1934. 6 x 9 inches. Cloth. 302 pages. $3.50. In the author's words, this book "is in no sense a treatise, or a handbook, but is frankly a textbook for students who are beginning their study of water supply engineering." It covers the field generally and briefly in 22 chapters embracing the fundamental requirements of municipal water supplies, the quantity and quality of water required, methods of examination, sources of supply, the relations of precipitation to water supply, characteristics of ground waters and of surface waters and their collection, the pumping and transportation of water, the treatment, distribution, and storage of water, and notes upon the operation, maintenance, and financing of water works systems. These subjects are discussed in the order naturally encountered in the preliminary planning of a water supply system. Tabular and graphical data are included to illustrate the generalizations developed in the text. While this book will probably not appeal to those engaged intimately in the practice of water supply engineering, it would seem to have a useful place as an informative reference to laymen interested in the subject and to public officials and others without previous experience newly charged with the administration of water supply matters. As a textbook for use in schools and colleges devoting brief courses to this subject, it should find considerable use.—*R. L. McNamee.*

CORRECTION

Drinking Water Supply of the Island of Heligoland, etc. This JOURNAL, 27: 7, 930–931. The last four lines, from the word Leipzig onwards, should be altered to the following: "it is therefore concluded that continuous, or lifelong, ingestion of water with even small amounts of lead, not exceeding 0.2 p.p.m., may be injurious to health. As a prophylactic measure, therefore, removal of all lead equipment was ordered.—*Manz.*"